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Characterization of Exhaust Emissions from Methanol- and Gasoline-Fueled Automobiles

Southwest Research Inst.
San Antonio, TX

Prepared for

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Emission Control Technology Division
2565 Plymouth Road
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Air

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Emission Control Technology Division
2565 Plymouth Road
Ann Arbor, Michigan 48105

August 1982

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This report was furnished to the Environmental Protection Agency by Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas, in fulfullment of Task Specifications 11 and 12 and Work Assignments 1 and 3 of Contract 68-03-2884 and 68-03-3073. The contents of this report are produced herein as received from Southwest Research Institute. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency. Mention of company or product names is not to be considered as an endorsement by the Environmental Protection Agency.

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FOREWORD

These project tasks and work assignments were initiated by the Control Technology Assessment and Characterization Branch, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105. The engineering and analytical effort on which this report is based was accomplished by the Department of Emissions Research of Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78284. The program tasks authorized by Task Specifications 11 and 12 under Contract 68-03-2884 and by Work Assignments 1 and 3 under Contract 68-03-3073 were initiated June 30, 1981, August 19, 1981, November 30, 1981, and January 8, 1982, respectively, and were completed March 1982. This program was identified within Southwest Research Institute as Projects 05-5830-011, 05-5830-012, 06-6619-001 and 05-6619-003.

The two initial project tasks were under the supervision of Mr. Charles Urban, Project Leader. Dr. Lawrence Smith, Senior Research Scientist, directed this program beginning November 7, 1981. Mr. Urban continued to be involved in major project decisions for the duration of the program. Mr. Charles Hare was Project Manager and was involved in the initial technical and fiscal negotiations and subsequent major program decisions. The EPA Project Officer was Mr. Robert J. Garbe of the Control Technology Assessment and Characterization Branch, Environmental Protection Agency, and the EPA Task Branch Technical Representative was Mr. Thomas M. Baines.

ABSTRACT

This report describes the laboratory effort to characterize regulated and unregulated exhaust emissions from four light-duty, spark-ignited automobiles. Two of the automobiles, a 1981 Ford Escort and a 1981 Volkswagen Rabbit, were evaluated with gasoline; one of these was also operated on a gasoline-alcohol blend. The two other vehicles, also a 1981 Escort and a 1981 Rabbit, were evaluated with methanol fuel. The automobiles were evaluated over the Light-Duty Federal Test Procedure (FTP) and the Highway Fuel Economy Driving Schedule (HFET). Additional evaluations with the methanol-fueled Escort and Rabbit were conducted using promoted base metal catalysts, and the Escort was evaluated in a non-catalyst configuration. Exhaust constituents measured, in addition to the regulated emissions, include: aldehydes (including formaldehyde), particulates, individual hydrocarbons, methanol, ethanol, ammonia, cyanide, amines, nitrosamines, and methyl nitrite. Additional exhaust evaluations included mass spectral and Ames bioassay analyses.

SUMMARY

The major objective of this program was to evaluate regulated and unregulated exhaust emissions from low mileage noble metal catalyst-equipped automobiles fueled with gasoline and methanol. Additional objectives involved the emissions characterization of these vehicles when low mileage promoted base metal catalysts were used, as well as the evaluation of a gasoline-methanol fuel blend (Anafuel). Four 1981 model year automobiles, two methanol-fueled (a Ford Escort and a Volkswagen Rabbit), were evaluated over two driving schedules, the light-duty Federal Test Procedure (FTP), and the Highway Fuel Economy Test (HFET). Additional multiple Urban Dynamometer Driving Schedules (UDDS) were used to generate particulate samples.

The exhaust emissions evaluated in this program included the regulated emissions (hydrocarbons, carbon monoxide, and oxides of nitrogen), aldehydes (including formaldehyde) and ketones, selected individual hydrocarbons, methanol, ethanol, ammonia, cyanide, organic amines, nitrosamines, and methyl nitrite. Additional evaluations involved the collection and extraction of particulate samples for Ames bioassay and mass spectral analyses.

Average FTP emission rates and fuel economy values for eight different vehicle, catalyst, and fuel combinations are summarized on the following page. The following observations are made for these data:

- The Ford Escort produced similar emissions and fuel consumption when operating on "Anafuel" and gasoline.
- The methanol-fueled cars had higher fuel consumption (but lower energy consumption), higher formaldehyde and methanol emissions, and lower particulate emissions than the corresponding gasoline-fueled cars.
- The methanol-fueled Escort had lower NO_x than its gasoline counterpart and the methanol-fueled Rabbit had higher NO_x than its gasoline counterpart. All vehicles had NO_x emissions below the 0.62 g/km (1.0 g/mi) level of the standard except for the promoted base metal-equipped Rabbit.
- In general, the promoted base metal catalyst and the factory-installed noble metal catalyst produced opposing results for the Escort and the Rabbit. The promoted base metal catalyst produced lower emissions from the Escort and higher emissions from the Rabbit. One reason for this may be that the Escort was tested with a larger promoted base metal catalyst than the Rabbit.

SUMMARY OF FTP EMISSIONS AND FUEL CONSUMPTION

Emissions in mg/km, except as noted

	1981 Ford Escorts[a]					1981 VW Rabbits[a]		
	Gasoline Configuration		Methanol Configuration			Gasoline Configuration	Methanol Configuration	
Fuel	Anafuel	Gasoline	Methanol	Methanol	Methanol	Gasoline	Methanol	Methanol
Catalyst	Factory	Factory	Factory	P.B.-Metal	No Catalyst	Factory	Factory	P.B.-Metal
Hydrocarbons, g/km	0.19	0.23	0.26	0.19	6.39	0.07	0.24	0.30
Carbon Monoxide, g/km	2.02	2.79	3.75	0.94	25.34	0.67	0.55	1.70
Oxides of Nitrogen, g/km	0.42	0.34	0.25	0.22	0.38	0.10	0.42	0.94
Fuel Cons., ℓ/100 km	9.6	9.6	18.7	18.5	19.1	9.9	17.0	16.9
Energy Cons., 10^6J/km	3.03	3.03	2.92	2.89	2.98	3.12	2.66	2.64
Particulates	4	6	4	2	7	7	3	4
Formaldehyde	<1	<1	21	2	221	ND	6	20
Methanol	ND[b]	ND	253	94	7126	ND	273	336
Methane	43	60	30	22	41	9	3	7
Ammonia	--[c]	--	6	3	2	--	--	--
Cyanide	--	--	ND	0.1	<0.1	--	--	--
Amines	--	--	<0.1	ND	0.4	--	--	--
Nitrosamines	ND	ND	ND	ND	ND	ND	ND	ND

[a] Total of four separate automobiles

[b] None detected

[c] Analysis not conducted

- Relative to results without a catalyst, the low mileage promoted base metal and the noble metal catalysts significantly reduced hydrocarbon, carbon monoxide, methanol, formaldehyde and organic amine emissions from the Ford Escort (85 to 100 percent reduction). Oxides of nitrogen, methane, and particulate emissions were reduced 30 to 65 percent with catalytic aftertreatment.

- Nitrosamines were not detected in the exhaust of any of the configurations evaluated.

- The exhaust hydrocarbons from methanol-fueled vehicles were found to be primarily methanol.

- Organic amine, ammonia, and cyanide emissions from methanol-fueled vehicles were similar to corresponding emissions from gasoline-fueled vehicles.

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I. INTRODUCTION

This report describes the effort to characterize regulated and unregulated exhaust emissions from automobiles fueled with methanol and a methanol-gasoline blend. Four automobiles were evaluated over a total of ten different vehicle catalyst and fuel combinations. Two of the combinations involved automobiles operating with gasoline to enable making direct emissions comparisons. This is the seventh program to be completed at SwRI involving a large number of unregulated emissions from automobiles. The previous projects involved evaluations of non-catalyst, oxidation catalyst-equipped, and three-way catalyst-equipped gasoline-fueled automobiles.(1,2,3,4,5,6)*

A. Project Objective

The primary objective of this project was to evaluate regulated and unregulated exhaust emissions from automobiles fueled with methanol. Evaluations were performed on four 1981 model-year automobiles over a total of ten different combinations of vehicles, fuels, and catalysts.

B. Emission Measurement Procedures

The compound or groups of compounds evaluated, along with the sampling methods used, were as follows:

Sampling Methods	Compounds Evaluated
Bag	HC, CO, NO_x, CO_2, Individual HC, ethanol and methyl nitrite
Filter	Particulates, organic soluble fraction of particulates for Ames Bioassay and mass spectral analyses
Impinger	Cyanides, aldehydes, ammonia, organic amines, and methanol
Trap	Nitrosamines and mass spectral analyses

Several of these procedures for measuring the unregulated emissions were developed in another project and reported in a widely distributed interim report.(7)

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*Superscript numbers in parentheses designate references at end of report.

C. Vehicles Evaluated

Four 1981 model year automobiles were evaluated in this project. Two of the four were methanol-fueled, a Ford Escort and a Volkswagen Rabbit, and two were gasoline-fueled, also a Ford Escort and a Volkswagen Rabbit. The two VW Rabbits were fuel injected, and all four vehicles were equipped with a three-way catalyst. These vehicles were obtained through the EPA Project Officer. The methanol-fueled Ford Escort was received from the Los Angeles County Mechanical Department. This vehicle was among the first of 40 such methanol-fueled vehicles built by Ford for the California Energy Commission (CEC) alcohol program. The methanol-fueled VW Rabbit was one obtained on loan from Volkswagen and was built on the same assembly line that produced the methanol-fueled VW Rabbits for the CEC alcohol program. The gasoline-fueled VW Rabbit was lent for use in this program by Volkswagen of America (Mr. Dan Hardin and Larry Nutson are among those responsible for this loan).

D. Fuels Evaluated

The three fuels evaluated in this program were gasoline, methanol and "Anafuel," (a gasoline-methanol blend). Two vehicles were tested in several catalytic converter configurations with methanol fuel. Two vehicle configurations were tested with a gasoline fuel, for comparison purposes, and one vehicle configuration was tested with "Anafuel."

E. Catalytic Aftertreatment Evaluations

The methanol-fueled Escort and VW Rabbit were evaluated with their original factory-provided noble metal catalysts and with promoted base metal catalysts. An additional evaluation was conducted on the Ford Escort without catalytic aftertreatment.

F. Vehicle Testing

Vehicle configurations evaluated in this study were generally tested in duplicate; in a few cases, triplicate tests were conducted. The test sequence included the Light-Duty Federal Test Procedure (FTP),(8) and the Highway Fuel Economy Driving Schedule (HFET).(9) Additional multiple Urban Dynamometer Driving Schedules (UDDS) were used to generate particulate samples for subsequent extraction for mass spectral and Ames Bioassay analyses.

II. GENERAL EQUIPMENT, INSTRUMENTS, PREPARATIONS AND PROCEDURES

This section describes the automobiles, the fuels, the facilities, and the general instrumentation and procedures utilized in this project. The overall sampling systems for the unregulated emissions are also discussed.

A. Automobiles

Four 1981 automobiles were evaluated in this project. These automobiles are described in Table 1, and several are shown in Figure 1. Two of the automobiles were designed to operate on methanol (a Ford Escort, Car 83, and a VW Rabbit, Car 84) and two on gasoline (a Ford Escort, Car 81, and a VW Rabbit, Car 85). All four of these automobiles were obtained through the EPA Project Officer. The four automobiles were evaluated in ten configurations, involving various combinations of fuels and catalysts. These ten combinations are described in Table 2.

B. Fuels

Three fuels were used in this program: gasoline, a methanol-gasoline blend, and methanol. The gasoline fuel, Amoco Indolene, was used in testing Car Configurations 81 and 85. This gasoline fuel is described in Table 3. The methanol-gasoline blend, "Anafuel", was used in testing Car Configuration 82. "Anafuel" consists of up to 12 volume percent methanol, up to 6 volume percent of certain four-carbon alcohols, and a proprietary inhibitor (of not less than 0.023 grams per gallon and not more than 0.033 grams per gallon) in unleaded gasoline. This fuel is described in the Federal Register Vol. 46, No. 192, Monday, October 5, 1981. Methanol, of 99.98 percent purity, was used in testing Car Configurations 83, 84, 86, 87, 88, 89, and 90. The methanol is described in Table 4.

C. Catalytic Aftertreatment Evaluations

The methanol-fueled Escort and Rabbit were evaluated with their original equipment noble metal catalysts and with promoted base metal catalysts. The promoted base metal catalyst material used in the program was supplied by Davison Chemical, a division of W. R. Grace. The active elements consisted of transition elements (but not nickel) plus 0.05 troy ounces of Palladium per substrate. The catalysts were packaged and installed into the vehicles by Southwest Research Institute. The promoted base metal catalysts, used on the Escort (Car Conf. 87) and the Rabbit (Car Conf. 86), are described in Appendices A-1 and A-2. The promoted base metal catalyst used in the testing of the Rabbit (Car Conf. 89), consisted of one-half the promoted base metal catalyst material previously used for the testing of the Ford Escort.

TABLE 1. AUTOMOBILES EVALUATED

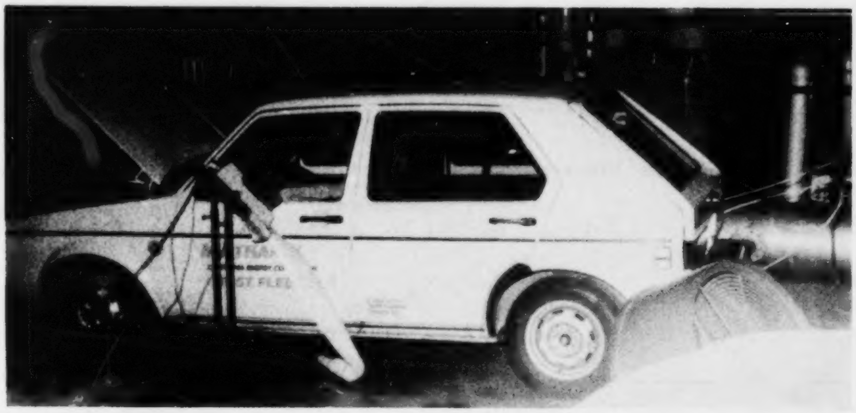
Project Car Numbers	Vehicle				
	Year	Make	Model	Body Type	ID or Serial Number
81 & 82	1981	Ford	Escort	Wagon	1FABP082XBW20356
83, 87, 88, & 90	1981	Ford	Escort	Wagon	1FABP0825BW225255
84, 86 & 89	1981	VW	Rabbit	4-dr	1VWFB01793V183756
85	1981	VW	Rabbit	4-dr	1VWGB9171BY085460

Project Car Numbers	Engine		Transmission	Fuel Delivery
	Disp.	Cyl.		
81 & 82	1.6	4	Manual -4	Carbureted
83, 87, 88, & 90	1.6	4	Auto. -3	Carbureted
84, 86 & 89	1.6	4	Auto. -3	Injected
85	1.7	4	Auto. -3	Injected

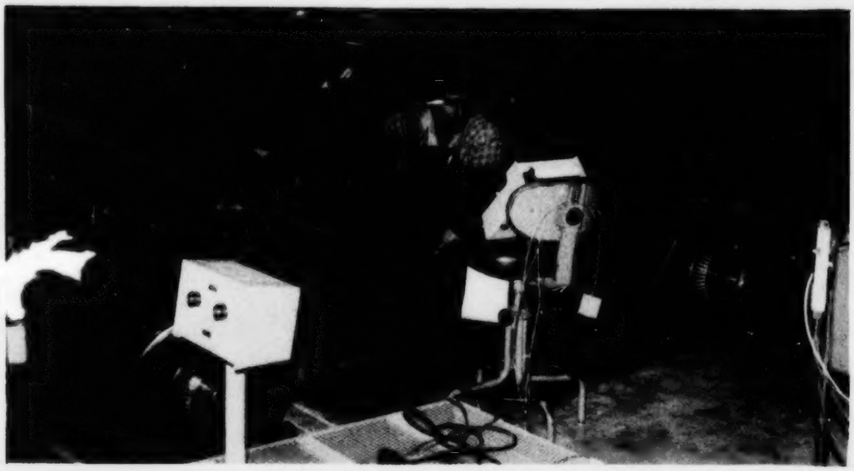
Project Car Numbers	Chassis Dynamometer Settings			
	Inertia Kilograms	Power Kilowatts	Inertia Pounds	Power Horsepower
81 & 82	1134	5.3	2500	7.1
83, 87, 88, & 90	1134	5.3	2500	7.1
84, 86 & 89	1134	5.7	2500	7.7
85	1134	5.7	2500	7.7

METHANOL
TEST FLEET

Car 83 - 1981 Methanol-Fueled Ford Escort



Car 84 - 1981 Methanol-Fueled VW Rabbit



Car 85 - 1981 Gasoline-Fueled VW Rabbit

Figure 1. Three of the automobiles evaluated in the program.

TABLE 2. AUTOMOBILE CONFIGURATIONS EVALUATED

Project Car Number*	Year	Make	Model	Fuel Used	Catalyst Used
81	1981	Ford	Escort	Indolene	Noble Metal
82	1981	Ford	Escort	Anafuel	Noble Metal
83	1981	Ford	Escort	Methanol	Noble Metal
84	1981	VW	Rabbit	Methanol	Noble Metal
85	1981	VW	Rabbit	Indolene	Noble Metal
86	1981	VW	Rabbit	Methanol	P.B. Metal
87	1981	Ford	Escort	Methanol	P.B. Metal
88	1981	Ford	Escort	Methanol	No Catalyst
89	1981	VW	Rabbit	Methanol	P.B. Metal
90	1981	Ford	Escort	Methanol	Noble Metal

---

*Cars 81 and 82 are the same car operating with two different fuels. Cars 83, 87, 88 and 90 are the same car operating with different catalyst configurations. Cars 84, 86, and 89 are the same car operating with different catalyst configurations.

Car 90 evaluation is car 83 with a new carburetor.

TABLE 3. PROPERTIES OF GASOLINE FUEL

SwRI Fuel Code		EM-338-F
Product Name		Amoco Indolene H01112R
Sample No.		D-06133
Octane, Research		97.7
Octane, Motor		89.5
Sensitivity, Clear		8.2
Gravity, API		60.6
Oxidation Stability, Min.		600
Lead, g/gal., AA		<0.002
Phosphorus, g/gal.		0.000
R.V.P., Bomb, PSI		9.0
Sulfur, %		0.009
Gum, mg/100 mℓ		0.4
FIA, Vol. %:	aromatics	22.8
	olefins	2.0
	saturates	75.2
Distillation, Evap.		
IBP, °F		92
5% point, °F		103
10% point, °F		121
20% point, °F		156
30% point, °F		188
40% point, °F		206
50% point, °F		217
60% point, °F		226
70% point, °F		237
80% point, °F		257
90% point, °F		309
95% point, °F		334
EP, °F		406
recovery, %		95.0

TABLE 4. PROPERTIES OF METHANOL FUEL

SwRI Fuel Code		EM-464-F
Product Name		DuPont Methanol
Octane Number[a]	RON	106-110
	MON	90-92
Vapor Pressure[a] psi at 38°C		5
Boiling Point[a] °C		65
Flash Point[a] °C		11

SPECIFICATIONS AND TYPICAL ANALYSES[b]

	Spec.	Typical Analysis
Methanol, wt %	min. 99.85	99.98
Specific gravity (25/25C)	--	0.78891
Distillation range (1 atm) First drop to dry, C	max. 1.0	0.5
Nonvolatiles, wt %	max. 0.0005	<0.0001
Acetone, wt %	max. 0.002	<0.0014
Acidity (as acetic acid), wt %	max. 0.0020	0.0013
Alkalinity (as ammonia), wt %	max. 0.00030	<0.00005
Carbonizable substances platinum cobalt scale (APHA)	max. 35	10
Permanganate test, minutes	min. 50	56
Color, platinum cobalt scale (APHA)	max. 5	0
Hydrocarbon test, clouding when diluted with 2 parts water	none	passes

---

[a] Obtained from literature, references 10, 11, 12, 13
[b] Obtained from DuPont Methanol Data Sheet

The Escort was also evaluated without catalytic aftertreatment. For this evaluation, the catalyst was replaced by a piece of exhaust tubing.

D. Dynamometer and CVS System

A Clayton Model ECE-50 chassis dynamometer with a direct-drive variable-inertia flywheel system, was utilized for all transient testing. This direct-drive inertia system simulates equivalent weight of vehicles from 455 kg (1000 lb) to 4025 kg (8875 lb), in 55 kg (125 lb) increments.

The constant volume sampler (CVS) used for these evaluations was SwRI CVS Number 2. This unit has a nominal capacity of 9.2 m^3/min (325 cfm). A nominal 460 mm (18 inch) diameter by 5 m (16 foot) long dilution tunnel was used between the intake filter and the CVS to enable sampling of particulates.

Partial views of the chassis dynamometer, the dilution tunnel and the intake to the CVS can be seen in Figure 2. Both the dynamometer and the CVS were calibrated, maintained and operated in accordance with the manufacturer's instructions and the appropriate sections of the Code of Federal Regulations applicable to light-duty vehicles.(8)

In addition to the 142 m^3/min (5000 cfm) cooling fan placed in front of the automobile, 42 m^3/min (1500 cfm) blowers were available to cool each rear wheel. These additional blowers were used only during the HFET driving cycle.

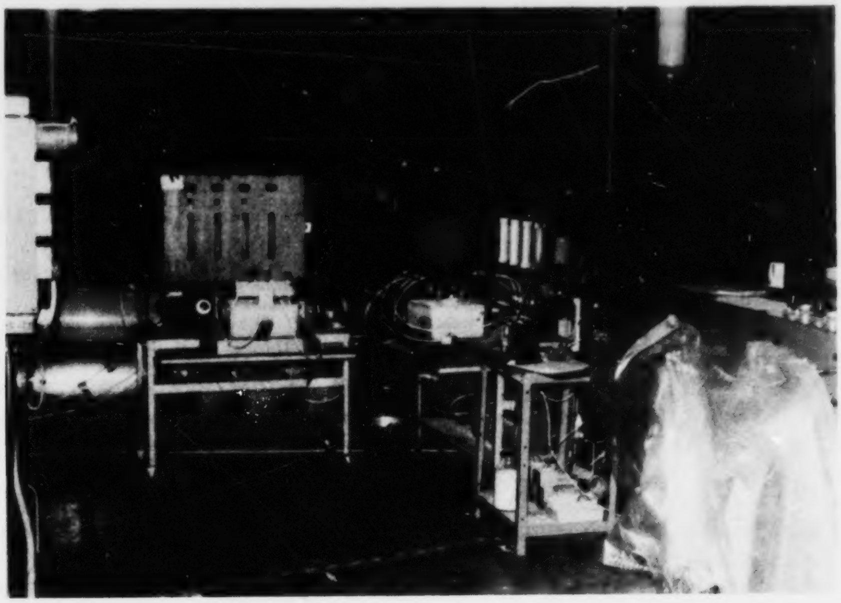
E. Exhaust Sampling and Analysis

A pictorial schematic of the exhaust and sampling system is shown in Figure 3. This system is in accordance with the guidelines established in previous unregulated emission projects conducted at SwRI for the EPA. The primary feature of this system is the number of sampling probes and systems necessary to collect all of the required unregulated emission samples. This complexity is illustrated in the views of the system shown in Figure 2.

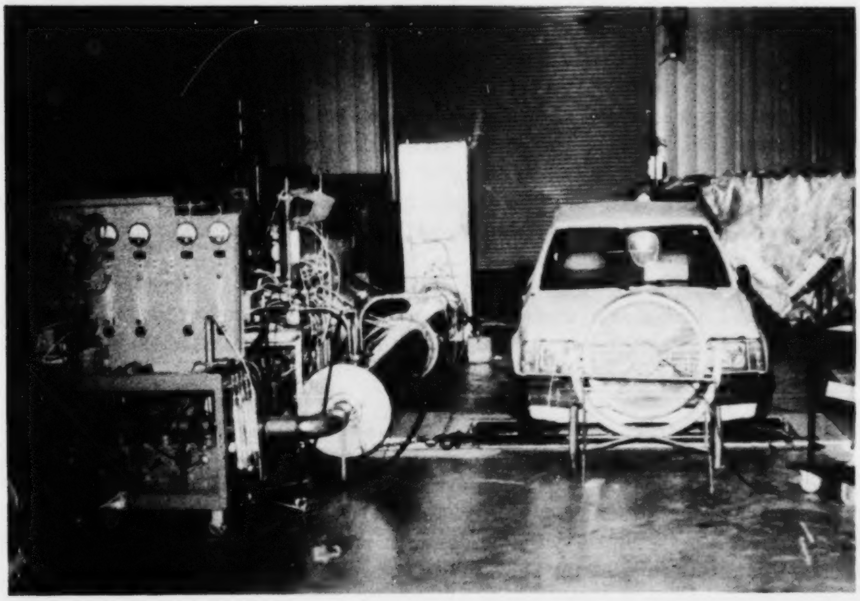
This section has described the dilution tunnel and provided some insight into the overall sampling system assembly. More details on each of the individual sampling systems for the unregulated emissions are given in Section III.

F. Instrumentation for Regulated Emissions and Engine Parameters

Bagged samples of the dilute exhaust were evaluated for HC, CO, NO_x, and CO_2 using SwRI Bag Cart Number 1. This bag cart was designed, calibrated and operated in accordance with the appropriate sections of the Code of Federal Regulations applicable to light-duty vehicles.(8)



CVS Side of System



Dynamometer Side of System

Figure 2. Views of the emissions sampling system

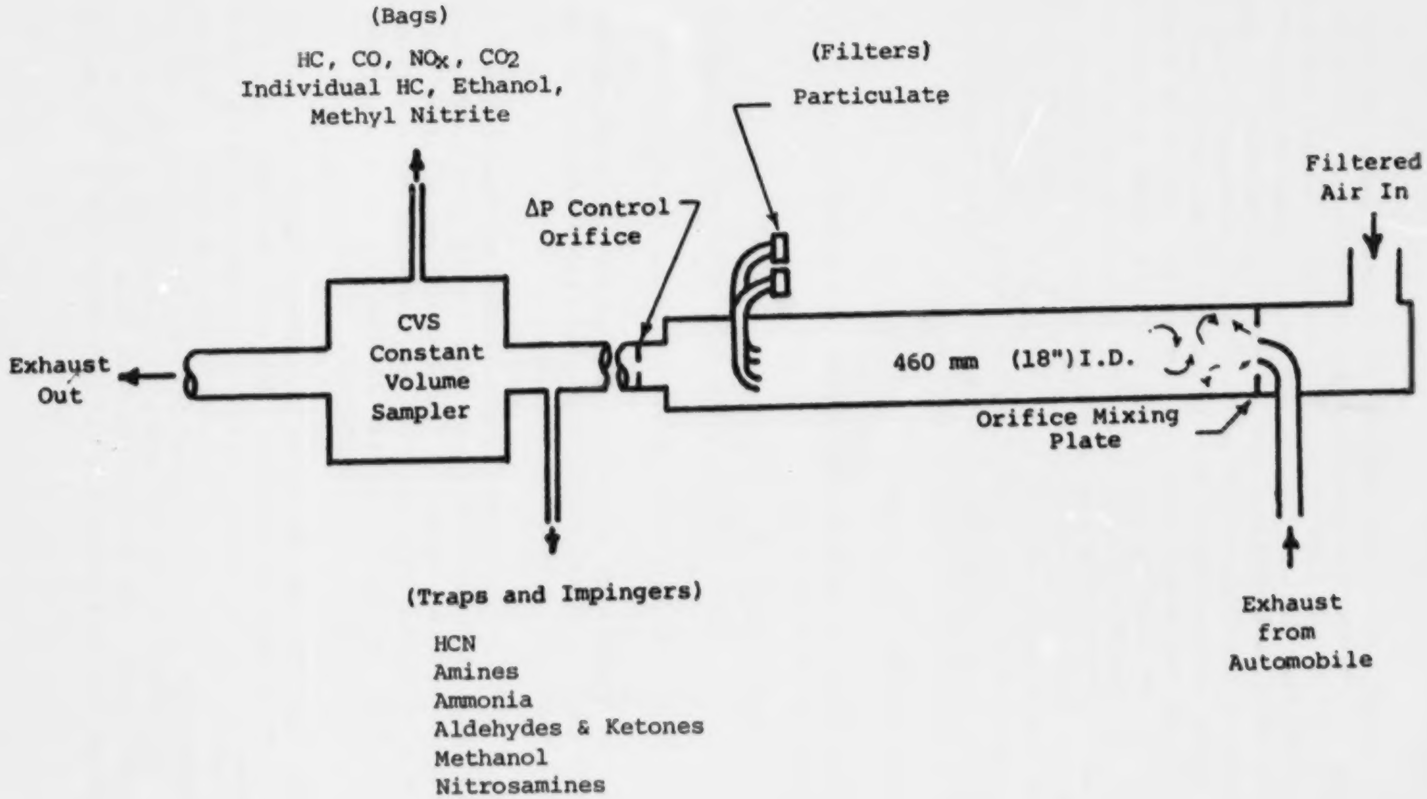

(Bags)
HC, CO, NO_x, CO_2
Individual HC, Ethanol,
Methyl Nitrite
(Filters)
Particulate
Filtered Air In
ΔP Control Orifice
CVS Constant Volume Sampler
460 mm (18")I.D.
Exhaust Out
Orifice Mixing Plate
(Traps and Impingers)
HCN
Amines
Ammonia
Aldehydes & Ketones
Methanol
Nitrosamines
Exhaust from Automobile

Figure 3. Emissions sampling system

G. Large Filter Samples

To obtain particulate samples for Ames Bioassay and mass spectral analyses, a system that allows the simultaneous collection of particulate on four 500 mm by 500 mm (20 inch by 20 inch) Pallflex filters was used in place of the regular CVS. Due to the low particulate emission rate of gasoline- and methanol-fueled automobiles, such a system is necessary to obtain sufficient quantities of particulate for extraction and subsequent analyses. This 20x20 filter system permits the collection of the total particulate generated by the automobile during a test cycle. The 20x20 filter system is attached to the sampling end of the dilution tunnel and consists of a positive displacement blower with four associated in-line 20x20 filters and filter holders, temperature and flowrate controllers and readouts. The nominal flowrate is held at 0.217 m^3/s (460 scfm) by maintaining a constant temperature, using a heat exchanger, and a constant pressure drop across the blower. With this flowrate, there was no difficulty in maintaining the tunnel temperature below 43°C (110°F). Maximum temperature was about 35°C (95°F) in most of the cycles.

H. Emissions Test Procedures

The primary procedures and driving schedules utilized in this project are defined as follows:

FTP - 1981 Federal Test Procedure(8)
(uses the Urban Dynamometer Driving Schedule)

HFET - Highway Fuel Economy Driving Schedule(9)

Each of the two primary procedures and schedules, requiring emissions testing in this project (FTP and HFET), utilized bagged samples for evaluation of regulated emissions and fuel consumption.

The HFET is a hot-start, single-segment driving cycle. The FTP, however, involved cold-start and hot-start, multi-cycle with multi-segment operation. In addition, in this project, a four-bag FTP was utilized for most of the unregulated emissions, rather than the three-bag FTP specified in the Federal Test Procedure. Therefore, before proceeding, it is important to clarify the meaning of FTP as used in this project.

FTP - The FTP uses the Urban Dynamometer Driving Schedule (UUDS) which is 1372 seconds in duration. The UDDS, in turn, is divided into two segments: a "transient" phase of 505 seconds and a "stabilized" phase of 867 seconds. The 1975 Federal Test Procedure consists of cold start "transient" and "stabilized" phases, followed by a hot start "transient". In this project, the hot start "transient" was followed by a hot start "stabilized". For the remainder of this discussion, and throughout this report, the four-cycle FTP will be identified as presented in Table 5.

A composite value in mass per distance for the three-cycle, three sample FTP regulated emissions is calculated using the following formula:

$$\frac{\text{MASS}}{\text{DISTANCE}} = \frac{0.43\times(\text{MASS 1} + \text{MASS 2})}{(\text{DIST. 1} + \text{DIST. 2})} + \frac{0.57\times(\text{MASS 3} + \text{MASS 2})}{(\text{DIST. 3} + \text{DIST. 2})}$$

For the four-cycle FTP, two-sample composite values determined in this project, the following formula was used:

$$\frac{\text{MASS}}{\text{DISTANCE}} = \frac{0.43\times M(1 + 2)}{(D1 + D2)} + \frac{0.57\times M(3 + 4)}{(D3 + D4)}$$

For both the three- and four-cycle FTP's, actual measured distances are used for each cycle in the calculations.

To illustrate the similarity of the three- and four-cycle FTP's, the following assumptions are made. Since the same driving cycle is involved, Distance 3 is essentially equal to Distance 1, and Distance 4 is essentially equal to Distance 2, therefore, these equations can be reduced to:

$$\text{3-FTP M/D} \simeq \frac{0.43\times(M1 + M2) + 0.57\times(M3 + M2)}{D1 + D2}$$

$$\text{4-FTP M/D} \simeq \frac{0.43\times M(1 + 2) + 0.57\times M(3 + 4)}{D1 + D2}$$

TABLE 5. DESCRIPTION OF FOUR-CYCLE FTP

	Four-Cycle FTP			
	Cold UDDS		Hot UDDS	
Cycle	1	2	3	4
Duration, seconds	505	867	505	867
Regulated Emissions, 3-Bag	X	X	X	
Regulated Emissions, 4-Bag	X	X	X	X
Unregulated Emissions:				
Bag	X	X	X	X
Impinger	---X---		---X---	
Trap	----------X----------			

NOTE: X designates a sample taken

Therefore, with the assumption that the changes in distance traveled are negligible, the composite results with the four-cycle FTP relative to results with the three-cycle FTP will differ only as the mass emissions emitted during Cycle 4 differ from those emitted during Cycle 2. For the regulated emissions, the differences during Cycles 2 and 4 were small, and the overall effects of such differences were essentially negligible.

The test sequence followed for each automobile is given in Table 6.

TABLE 6. TEST SEQUENCE FOR EACH AUTOMOBILE CONFIGURATION

Sequence	Operation Performed on Each Vehicle Configuration
Upon Receipt	Drain and fill with test fuel, install and leak-check exhaust adapter, install proper catalytic converter Precondition with UDDS
1	Run FTP, HFET - Sample and analyze emissions
2	Run FTP, HFET - Sample and analyze emissions
3	Run FTP, HFET - Sample and analyze emissions[a]
4	Run multiple UDDS sequences (nine) - Sample with 20x20 Pallflex filters for Ames Bioassay analyses[b]
5	Run multiple UDDS sequences (nine) - Sample with 20x20 Pallflex filters for Ames Bioassay analyses
6	Run FTP - Sample and analyze for methyl nitrite[c]
7	Run multiple UDDS sequences (nine) - Sample with 20x20 Pallflex filters and Tenax GC traps for mass spectral studies[d]
8	Run multiple UDDS sequences (nine) - Sample with 20x20 Pallflex filters and Tenax GC traps for mass spectral studies

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[a] Only two FTP, HFET sequences were run for Car Configurations 88, 89 and 90.
[b] Multiple UDDS sequences were not run on Car Configuration 86.
[c] Methyl nitrite evaluations were performed only on Car Configurations 83, 84, 85, and 86. An additional FTP was run on car 84 and an additional HFET was run on car 83.
[d] Mass spectral studies were performed only on Car Configurations 84 and 85.

The sequence followed in the laboratory for running one set of emissions tests (FTP and HFET) is given in Table 7. The sequence followed in the laboratory for running each multiple UDDS sequence is given in Table 8.

TABLE 7. LABORATORY TEST SEQUENCE

1. Precondition, UDDS
2. Soak 12 to 20 hours
3. FTP - 4 bags for gaseous emissions
   2 filters or impinger samples
4. Engine Off - 10 minutes - Fan Off
5. HFET - 1 bag sample
   1 filter or impinger sample

Note: 5000 cfm fan on during all car operation. Additional tire and fuel tank cooling blowers on during all HFET operation.

TABLE 8. LABORATORY TEST SEQUENCE FOR MULTIPLE UDDS SEQUENCE

1. Precondition, UDDS
2. Soak 12 to 20 hours
3. Cold Start UDDS
4. Engine Off - 10 minutes - Fan Off
5. Hot Start UDDS
6. Engine Off - 10 minutes - Fan Off
7. Repeat Steps 5 and 6
8. Repeat Steps 5 and 6
9. Repeat Steps 5 and 6
10. Force cool engine with fan on for one hour
11. Force cooled cold start UDDS
12. Engine Off - 10 minutes - Fan Off
13. Repeat Steps 5 and 6
14. Repeat Steps 5 and 6
15. Repeat Steps 5 and 6

The parameters of the two primary driving schedules are summarized in Table 9, and these schedules are illustrated in Figure 4. Other driving schedule designations frequently used are as follows:

Driving Schedule Designation Used	Other Common Designations
FTP	LA-4 and UDDS
HFET	FET

TABLE 9. SUMMARY OF DRIVING SCHEDULE PARAMETERS

Schedule	Duration, Seconds	Distance, Kilometers	Average Speed km/hr	Average Speed mph
FTP:				
505	505	5.8	--	--
867	867	6.2	--	--
UDDS	1372	12.0	31.4	19.5
HFET	765	16.5	77.6	48.2

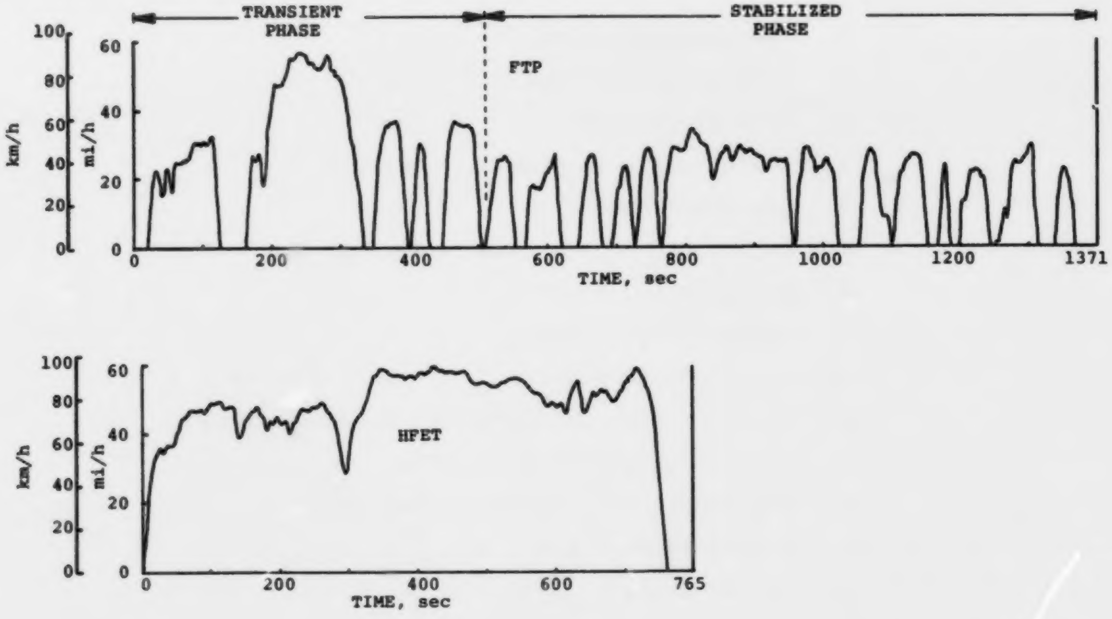

Figure 4. Driving cycle speed vs time traces

I. Test Numbering System

The numbering system used in this project consists of three digits plus a cycle abbreviation. The designation used for all automobile testing was "VCT", followed by the individual test cycle abbreviation FTP or FET. The meaning of each leter is described as follows:

Code	Description	As Used in This Project
VC	Vehicle Configuration	81 thru 90
T	Test Series	1 thru 3

J. Computational Methods

The methods used for calculating the unregulated emissions results are given in Appendix A-3. All regulated emissions were calculated using the methods prescribed in the Code of Federal Regulations for Light-Duty Vehicles.(8) On the computer printouts for the regulated emissions (Appendix D), all items of potential interest are identified by descriptive headings. Items on the computer sheet identified only by abbreviated headings are used in calculating the unregulated emissions.

III. ANALYTICAL PROCEDURES FOR UNREGULATED EMISSIONS

The analytical procedures used to measure the unregulated emissions are summarized in this section. Detailed descriptions for several of the procedures, along with discussions of their development, validation, and qualifications, are available in the EPA report, "Analytical Procedures for Characterizing Unregulated Pollutant Emissions from Motor Vehicles."(7)

A. Description of the Analytical Procedures

The unregulated emissions evaluated in this project, along with the methods for sampling and the procedures used in the analyses, are listed in Table 10. Organic amines, aldehydes and ketones, and individual hydrocarbons represent groups of compounds. The respective procedures separate and identify a number of individual components within each of these groups. The analytical procedures involved in this project are briefly described as follows:

Organic Amines - The collection of organic amines (monomethylamine, monoethylamine and dimethylamine, trimethylamine, diethylamine, and triethylamine) is accomplished by bubbling CVS-diluted exhaust through glass impingers containing dilute sulfuric acid. The amines are complexed by the acid to form stable sulfate salts which remain in solution. A portion of this solution is then injected into a gas chromatograph equipped with an ascarite loaded pre-column and a nitrogen-phosphorus detector (NPD). External amine standards in dilute sulfuric acid are used to quantify the results.

Ammonia - Ammonia in CVS-diluted automotive exhaust is measured in the protonated form, NH_4^+, after collection in dilute H_2SO_4. The acidification is carried out in a glass impinger maintained at ice bath temperature. A sample from the impinger is then analyzed for ammonia in an Ion Chromatograph and the concentration in the exhaust is calculated by comparison to an ammonium sulfate standard solution.

Aldehydes and Ketones - The collection of aldehydes (formaldehyde, acetaldehyde, isobutyraldehyde and hexanaldehyde) and ketones (acetone and methylethylketone) is accomplished by bubbling CVS-diluted exhaust through glass impingers containing 2,4-dinitrophenylhydrazine (DNPH) in dilute hydrochloric acid. The aldehydes and ketones (also known as carbonyl compounds) react with the DNPH to form their respective phenylhydrazone derivatives. These derivatives are insoluble or only slightly soluble in the DNPH/HCl solution and are removed by filtration followed by pentane extractions. The filtered precipitate and the pentane extracts are combined and then the pentane is evaporated in a vacuum oven. The remaining dried extract contains the phenylhydrazone derivatives. The extract is

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TABLE 10. SAMPLING AND ANALYSIS METHODOLOGY FOR UNREGULATED EMISSIONS

Compound	Sampling	Method of Analysis
Organic Amines	Impinger	Gas Chromatograph with ascarite precolumn and nitrogen-phosphorus detector (GC-NPD).
Ammonia (NH_3)	Impinger	Ion Chromatograph.
Aldehydes & Ketones	Impinger	Dinitrophenylhydrazone derivative. Gas Chromatograph with flame ionization detector (GC-FID).
Total Cyanide [Hydrogen Cyanide (HCN) and Cyanogen (C_2N_2)]	Impinger	Cyanogen chloride derivative. Gas Chromatograph with electron capture detector (GC-ECD).
Individual Hydrocarbons	Bag	Gas Chromatograph with flame ionization detector (GC-FID).
Particulates	Filter	Weighed using microbalance.
Methanol	Impinger	Gas Chromatograph with flame ionization detector (GC-FID).
Ethanol	Bag	Gas Chromatograph with flame ionization detector (GC-FID).
Methyl Nitrite	Bag	Gas Chromatograph with mass spectrometer.
Nitrosamines	Trap	Gas Chromatograph with TEA detector.

dissolved in a quantitative volume of toluene containing a known amount of anthracene as an internal standard. A portion of this dissolved extract is injected into a gas chromatograph and analyzed for several individual aldehydes and ketones using a flame ionization detector.

Total Cyanide (Hydrogen Cyanide plus Cyanogen) - The collection of total cyanide is accomplished by bubbling CVS-diluted exhaust through glass impingers containing a 1.0 N potassium hydroxide absorbing solution. This solution is maintained at ice bath temperature. An aliquot of the absorbing reagent is then treated with KH_2PO_4 and Chloramine-T. A portion of the resulting cyanogen chloride is injected into a gas chromatograph equipped with an electron capture detector (ECD). External CN^- standards are used to quantify the results.

Individual Hydrocarbons - For measurement of selected individual hydrocarbons, methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2) propane (C_3H_8), propylene (C_3H_6), benzene (C_6H_6), and toluene (C_7H_8), a sample of CVS-diluted exhaust is collected in a Tedlar bag. This bagged sample is then analyzed for individual hydrocarbons using a gas chromatographic system containing four separate columns and a flame ionization detector. The peak areas are compared to an external calibration blend and the individual hydrocarbon concentrations are obtained using a Hewlett-Packard 3354 computer system.

Methanol - The measurement of methanol in exhaust is accomplished by bubbling the exhaust through glass impingers containing deionized water. The exhaust sample is collected continuously during the test cycle. For analysis, a portion of the aqueous solution is injected into a gas chromatograph equipped with a flame ionization detector (FID). External methanol standards, consisting of methanol in deionized water, are used to quantify the results. Detection limits for this procedure are on the order of 0.06 ppm in dilute exhaust. This procedure is described in detail in Appendix A-4.

Ethanol - The measurement of ethyl alcohol in exhaust is accomplished by direct bag analysis using a gas chromatograph equipped with a flame ionization detector. The exhaust sample is collected continuously during the test cycle. External ethanol standards, consisting of ethanol in zero air, are used to quantify the results. Detection limits for this procedure are on the order of 0.6 ppm in dilute exhaust. A more detailed description of this procedure can be found in the Final Report of Task No. 6, Contract 68-03-2377, "Gasohol, TBA, MTBE Effects on Light-Duty Emissions."(14)

Methyl Nitrite - The measurement of methyl nitrite in exhaust was accomplished by collecting dilute exhaust in Tedlar bags and analyzing the collected sample with the aid of a gas chromatograph (GC) coupled to a mass spectrometer. The GC analytical column used in the analysis consisted of a 5' x 2 mm glass column packed with Chromosorb 101. The temperature program for the gas chromatograph involved isothermal operation at 25°C for 4 minutes, followed by an increase to 240°C at a rate of 10°C per minute. Selected ion masses of 30, 31, 60 and 61 amu were monitored with the mass spectrometer, which was operating at an electron energy of 70 ev. Samples were admitted to the GC using a 5.8 mℓ Teflon sample loop. Methyl nitrite, for use as a standard, was prepared by dropwise addition of dilute sulfuric acid to a solution of sodium nitrite in aqueous methanol. The evolved methyl nitrite gas was collected in a cold trap (-70°C) and transferred to a cooled, evacuated stainless steel gas bomb. Working standards were prepared in Tedlar bags, by diluting portions of this stock standard with helium. Due to the water in the exhaust samples, the methyl nitrite peak was considerably broadened as it eluted from the gas chromatograph. As a result of this broadening the detection limits for the procedure were only on the order of 0.3 ppm.

Nitrosamines - The collection of nitrosamines (n-nitrosodimethylamine, N-nitrosodiethylamine, N-nitrosodipropylamine, N-nitrosodibutylamine, N-nitrosopiperidine, and N-nitrosopyrrolidine) is accomplished by passing CVS-diluted exhaust through ThermoSorb/N traps at a flow rate of 2 liters per minute. One sample is taken over several FTP test cycles to improve the detection limits. After sample collection, the ThermoSorb/N traps are sent to the Thermo Electron Corporation for analysis. At Thermo Electron the traps are backflushed with a 25/75 solution of methanol in dichloromethane. The first 1.5 to 1.8 mℓ of this eluant are saved for GC-TEA analysis. The GC-TEA instrument detection limits range from 5 ng for N-nitrosodimethylamine to 10 ng for N-nitrosodibutylamine. Additional information on the ThermoSorb/N traps and the GC-TEA analyzer can be found in the Task 2 Final Report of EPA Contract 68-03-2884, "Nitrosamines in Vehicle Interiors."(15)

Particulate - The "particulate" is collected on a 47 mm glass fiber filter. The amount of "particulate" collected is determined by weighing the filter on a microbalance before and after sampling.

B. Validation and Qualification of the Analytical Procedures

Several of the procedures used in this project were subjected to a series of validation and qualification experiments in previous projects. Validation experiments included checks for sample stability, sample collection efficiency, detector linearity, interferences, and analysis repeatability. Qualification experiments included the injection of the compound of interest into the dilution tunnel with and without the presence of exhaust and the subsequent recovery of that compound at the procedure sampling point.

Sample stability checks were performed using repeated analyses of the same sample at intervals over a specified period of time, and comparing the results to the initial analysis. Organic amines, aldehydes and ketones, ammonia, total cyanide, nitrous oxide and individual hydrocarbon samples were found to be stable for several days. Carbonyl and organic sulfides and the hydrogen sulfide samples were found to be stable for approximately one day.

Sample collection efficiency experiments were performed by passing a known concentration of sample through a series of impingers or traps and analyzing each impinger or trap individually for the compound of interest. All of these procedures used in this project had a collection efficiency of 98% or better. Detector linearity experiments were performed by preparing several samples of various known concentrations and plotting the resulting peak areas versus the concentrations. The procedures had linear response over the range of interest in this project.

To determine interferences from other compounds, for each procedure, known exhaust components were introduced into the sample to determine their effect on the resultant measurements. To determine analysis repeatability, several samples of known concentrations were prepared and a number of complete analyses were performed at each concentration. The results of these tests were then compared to determine analysis repeatability.

The qualification experiments were performed to determine if the compounds of interest could travel the length of the dilution tunnel in the presence of dilute exhaust without significant loss by reaction with exhaust or the tunnel itself. The compounds were introduced at the sample point at which the exhaust enters the tunnel and were sampled at the normal sampling point. Table 11 lists the procedures for which validation and qualification experiments have been performed.

TABLE 11. PROCEDURAL VALIDATION AND QUALIFICATION

Compound or Compound Group	Validation Conducted	Qualification Conducted
Organic Amines	Yes	Yes (significant tunnel losses)
Ammonia	Yes	Yes (significant tunnel losses)
Aldehydes & Ketones	Yes	Yes
Total Cyanide	Yes	Yes
Individual Hydrocarbons	Yes	No[a]
Particulates	No[a]	No[a]

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[a] Established procedure

C. Accuracy of the Analytical Procedures

A difficult, but very important endeavor was the determination of procedural accuracy for each analytical method. The primary difficulty involved those procedures in which the exhaust compounds are trapped or absorbed, an extraction or subsequent reaction is performed, and then a portion of the extract is analyzed. After much consideration, in previous unregulated emission projects, the decision was reached to initially define the accuracy in terms of a "minimum detection value" (MDV). The MDV, as used in this report, is defined as the value above which it can be said that the compount has been detected in the exhaust (i.e., at a measured value equal to the MDV, the accuracy is equal to plus or minus the MDV). Determination of accuracy over the entire range of each procedure was beyond the scope of these projects.

For compounds collected by bag samples, the MDV was determined from the instrument detection limits only, and is independent of the sampling rate and duration. For compounds which are concentrated in impingers or traps, the MDV is dependent on the instrument detection limit, chemical workup, sampling rate and sampling duration. The MDV's listed in Table 12 were derived using the listed sampling rate and a 23-minute sampling period.

TABLE 12. EMISSION PROCEDURAL SAMPLE RATES AND ACCURACY

		Mol. Weight	Sample Flow ℓ/min	$\mu g/m^3$ per ppm	Procedural Minimum Detection Values[a] ppm	$\mu g/m^3$	MDV for FTP mg/km[b]
Test Number,	VCT	---	--	--	--	--	--
Barometer,	mm HG	---	--	--	--	--	--
Humidity,	g/kg	---	--	--	--	--	--
Temperature	°C	---	--	--	--	--	--
Carbon Dioxide,	g/km	44.01	Bag	--	--	--	--
Fuel Cons.,	ℓ/100 km	---	--	--	--	--	--
Regulated Emissions							
Hydrocarbons (THC)		11.88	Bag	575	1.0[c]	575	10
Carbon Monoxide		28.01	Bag	1165	2.0[c]	2330	40
Oxides of Nitrogen		46.01	Bag	1915	0.5[c]	958	16
Particulates							
Total Particulates		---	14.0	--	--	<50	<1
Compound Group Totals							
Aldehydes & Ketones		---	4.0	--	--	--	≈0.5
Individual Hydrocarbons		---	Bag	--	--	--	≈0.5
Organic Amines		---	4.0	--	--	--	≈0.1
Nitrosamines		---	2.0	--	--	--	<0.001[d]
Other Compounds							
Ammonia		17.03	4.0	710	0.01	7	0.1
Cyanide & Cyanogen		26.02	4.0	1080	0.01	11	0.2
Methanol		32.04	4.0	1333	0.06	80	1.3
Ethanol		46.07	Bag	1916	0.6	1150	19.6
Methyl Nitrite		61.04	Bag	2539	0.3	762	e

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[a] Based on a 23-minute sampling period at the specified flow rate for all impinger, filter and trap collected samples.

[b] Based on $\mu g/m^3$ in the diluted exhaust and typical UDDS (FTP 505 and 867) parameters (1372 seconds, 206 m^3 CVS flow, 12.07 km, 0.98 DSFC).

[c] Based on the lowest instrument ranges used in this project.

[d] Based on sampling for six 23-minute periods, three 4-bag FTP's.

[e] Not applicable.

TABLE 12 (Cont'd). EMISSION PROCEDURAL SAMPLE RATES AND ACCURACY

	Mol. Weight	CRC[c] Synonym	$\mu g/m^3$ per ppm	Procedural Minimum Detection Values[a]		MDV for FTP mg/km[b]
				ppm	$\mu g/m^3$	
Aldehydes and Ketones						
Formaldehyde	30.03	--	1250	0.01	15	0.2
Acetaldehyde	44.05	--	1830	0.01	20	0.3
Acetone[d]	58.08	2-Propanone	2415	0.01	25	0.4
Methylethylketone	72.12	2-Butanone	3000	0.01	30	0.5
Hexanaldehyde	100.16	Hexanal	4165	0.01	40	0.7
Individual Hydrocarbons						
Methane	16.04	--	665	0.05	30	0.5
Ethylene	28.05	Ethene	1165	0.03	30	0.5
Ethane	30.07	--	1250	0.03	30	0.5
Acetylene	26.04	Ethyne	1085	0.03	30	0.5
Propane	44.11	--	1835	0.02	30	0.5
Propylene	42.08	Propene	1750	0.02	30	0.5
Benzene	78.12	--	3245	0.02	30	0.5
Toluene	92.15	--	3830	0.02	30	0.5
Organic Amines						
Monomethylamine	31.06	Amino-Methane	1290	0.002	3	0.05
Monoethylamine[e]	45.09	Amino-Ethane	1875	0.002	4	0.05
Trimethylamine	59.11	--	2460	0.002	5	0.08
Diethylamine	73.14	--	3040	0.002	6	0.10
Triethylamine	101.19	--	4205	0.002	8	0.14

[a&b] See initial page of this table.

[c] Handbook of Chemistry and Physics, 54th Edition.

[d] Includes Acrolein -56.07 and Propionaldehyde - 58.08 (CRC - Propenal and Propanal, respectively).

[e] Includes Dimethylamine - 45.09.

IV. VEHICLE TESTING

Regulated and unregulated exhaust emissions were measured from four automobiles in a total of ten different vehicle, fuel, and catalyst configurations. This section describes those evaluations and presents the test results.

A. Vehicle, Fuel, and Catalyst Configurations Evaluated

The vehicle, fuel, and catalyst configurations evaluated in this program are described in Table 13, along with the number and types of tests performed. The configurations selected permit comparisons of emissions data relative to the fuel (Indolene to "Anafuel" and to methanol) and the catalyst (no aftertreatment to catalytic aftertreatment, and noble metal to promoted base metal catalysts). The gasoline-fueled Escort was evaluated with both Indolene (Conf. 81) and "Anafuel" (Conf. 82) to permit a comparison of emissions from these two fuels; and the Indolene also provided the gasoline baseline data for comparison with the methanol-fueled Escort. Both the methanol-fueled Escort and Rabbit were evaluated with their factory-installed noble metal catalysts (Configurations 83 and 84) and with promoted base metal catalyst materials supplied by the Davison Chemicals Division of W. R. Grace (Configurations 86 and 87).

In the promoted base metal catalyst evaluation of the VW Rabbit, Configuration 86, the promoted base metal catalyst material sent by W. R. Grace and initially used, was subsequently determined to have only one-thirteenth the total surface area of the original-equipment noble metal catalyst. This is because the catalyst sent was on a substrate normally used for experimental diesel traps. Also, during the evaluation of this promoted base metal catalyst, small pieces of catalytic material were found in the dilution tunnel. When the catalyst container was cut open, it was found that only one-half of the catalyst was remaining. The VW Rabbit was reevaluated (Car Conf. 89) using one-half of the promoted base metal catalyst material previously used for testing of the Ford Escort.

The promoted base metal catalyst unit used in the reevaluation had approximately the same surface area as the original equipment noble metal catalyst. A comparison of the average FTP emissions from the reevaluation of the promoted base metal catalyst (Car Conf. 89) with the average emissions from the initial evaluation (Car Conf. 86) is made as follows:

TABLE 13. AUTOMOBILE CONFIGURATIONS EVALUATED

Car Conf.[a]	Model	Fuel Used	Catalyst Used	Replicate FTP-HFET Tests	FTP's for Methyl Nitrite Analysis	Multiple UDDS sequences - Ames Bioassay	Multiple UDDS Sequences - Mass Spectral Study
81	Escort	Indolene	Noble Metal	3	--[e]	2	--
82	Escort	Anafuel	Noble Metal	3	--	2	--
83	Escort	Methanol	Noble Metal	3	1[f]	2	--
84	Rabbit	Methanol	Noble Metal	3	2	2	2
85	Rabbit	Indolene	Noble Metal	3	1	2	2
86	Rabbit	Methanol	Base Metal[b]	3	1	0[g]	--
87	Escort	Methanol	Base Metal	3	--	2	--
88	Escort	Methanol	No Catalyst	2	--	1	--
89	Rabbit	Methanol	Base Metal[c]	2	--	2	--
90	Escort[d]	Methanol	Noble Metal	2	--	--	--

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[a] Cars 81 and 82 are the same car operating with two different fuels. Cars 83, 87, 88 and 90 are the same car operating with different catalyst configurations. Cars 84, 86 and 89 are the same car operating with different catalyst configurations.

[b] Promoted base metal catalyst provided by W.R. Grace for the VW Rabbit. Catalyst substrate of a type normally used for experimental diesel particulate traps.

[c] Base-metal catalyst consisted of half of the unit used for Car 87.

[d] Car 90 evaluation is Car 83 with a new carburetor.

[e] No test in this configuration.

[f] An HFET test was also run.

[g] Test was run on Car Configuration 89 in place of Car Configuration 86.

	Average FTP Emissions, mg/km	
Car Conf. No.	86	89
Catalyst	Promoted Base Metal (Initial Evaluation)	Promoted Base Metal (Reevaluation)
Hydrocarbons	540	300
Carbon Monoxide	2240	1700
Oxides of Nitrogen	1090	940
Methanol	573	336
Formaldehyde	30	20

The emissions were all lower in the reevaluation of the promoted base metal catalysts for the five emissions which were observed to differ in the two evaluations. In the reevaluation, relative to the initial promoted base metal catalyst evaluation, emissions decreased from 14 percent for NO_x to 44 percent for hydrocarbons.

To provide information on the magnitude of the emissions being produced by the engine and on the effectiveness of the aftertreatment (promoted base metal and noble metal catalysts), the methanol-fueled Escort was evaluated in a non-catalyst configuration (Car Configuration 88). A piece of exhaust tubing was used in place of the catalyst during the testing.

During the repetitive UDDS cycles to collect particulate on 20x20 filters in the non-catalyst configuration, the Escort (Car Conf. 88) began to experience difficulties in following the driving trace and finally could not be driven without repeatedly stalling. SwRI checked the fuel pump, the fuel filter, and the float level on the carburetor. To check the fuel pump, SwRI replaced the unit with an OEM gasoline-fueled application unit. The fuel bowl on the carburetor contained a significant amount of particulate (apparently due to corrosion). The Project Officer was alerted to this finding and he, in turn, contacted Ford Motor Company. Ford indicated that the as-received carburetor in the Escort was susceptible to corrosion from methanol, and it was postulated that this corrosion caused the carburetor to malfunction. Ford Motor Company sent an engineer to SwRI to replace the carburetor on the Escort with a newer, more corrosion-resistant model. The engineer replaced the carburetor and the fuel pump on the Escort, and made the appropriate adjustments for proper vehicle operation.

After the carburetor and fuel pump were replaced, the Escort was found to operate in essentially the same manner as it had when it was first received at SwRI. The Ford Escort was reevaluated with this new carburetor, using the original factory-installed noble metal catalyst (Car Conf. 90). These data were used for a comparison with the baseline emissions data obtained earlier in the program (Car Conf. 83). This comparison of the FTP emissions and fuel consumption is summarized as follows:

	FTP Emissions, mg/km	
Car Conf. No.	83	90
Carburetor	as-received	new
Hydrocarbons	260	290
Carbon Monoxide	3750	1420
Oxides of Nitrogen	250	250
Total Particulates	4	3
Methanol	253	263
Formaldehyde	21	11
Fuel Consumption, ℓ/100 km	18.7	18.2

The above data indicate the Escort was operating slightly richer with the as-received carburetor. With the new carburetor and fuel pump, carbon monoxide emissions were 62 percent lower and fuel consumption appeared to be 3 percent lower. Particulates and formaldehyde also appeared to be lower with the new configuration, 24 to 44 percent, respectively. However, hydrocarbons (12 percent) and methanol (4 percent) appeared to have increased after the carburetor replacement, and NO_x was unchanged.

B. Regulated and Unregulated Emissions Tests Results

Summaries of the test results are included in Appendix B. Individual sample data for the FTP evaluations are included in Appendix C, and the computer printouts for the regulated emissions are included in Appendix D. The analyses and discussion of these test results are included in Section V of this report. Methanol, ethanol, aldehyde, particulate and individual hydrocarbon emissions data are based on appropriately weighted four-cycle FTP results. Cyanide, ammonia, amines, and nitrosamines emissions data are based on unweighted four-cycle FTP results (i.e., one sample taken over an entire four-cycle test for the cyanide, ammonia, and amines, and one sample taken over three four-cycle tests for the nitrosamines).

In these data tables, a double dash (--) has been used when no test data were available. This occurs for the unregulated emissions when valid test data could not be obtained due to instrument malfunction or loss of the sample. Blanks are left in the tables where the analyses were excluded in accordance with the program scope of work.

C. Methyl Nitrite Sampling and Results

As described in Table 13, analyses for methyl nitrite were conducted on four Car Configurations (83, 84, 85, and 86). The bag samples taken for methyl nitrite analyses were collected using the standard CVS flowrate of 9.2 m^3/min (325 scfm). Using methanol fuel, this flowrate resulted in the minimum consistent dilution ratio at which water vapor would not condense in the sample bags. Dilution ratio is an important issue in the analyses of methyl nitrite, since the formation rate of methyl nitrite is a function of the concentration of the components from which it is formed. This point is discussed as follows:

Methyl Nitrite (MeONO) is formed in the reaction of methanol and nitrogen dioxide (NO_2):

$$MeOH + 2NO_2 \rightleftarrows MeONO + HNO_3$$ (16)

This reaction occurs at temperatures below 400 to 458°K (260 to 365°F) (16,17) and at a rate proportional to, at least, the square of the NO_x concentration. (17)

Nitrogen dioxide concentrations emitted from a car are generally only a very small percentage of the total NO_x. The rate for conversion in air from NO to NO_2 is as follows:

	Time to conversion in minutes* (18)		
ppm NO	25%	50%	90%
100	14	40	360
10	140	400	3600
1	1400	4000	40000

*Values have been rounded off for clarity

Based on these NO to NO_2 reaction rates, the overall reaction rate from NO in the dilute exhaust to MeONO would be on the order of the cube of the NO concentration (i.e., a 10:1 dilution would apparently result in about a 1000-fold decrease in the reaction rate to MeONO).

Therefore, the concentration of MeONO formed is essentially a direct function of the sampling parameters. Only at low dilution ratios has any appreciable MeONO been detected in exhaust samples; occurring in two previous studies reported in the literature. (16,17)

The results of the methyl nitrite analyses are given in Table 14. Only three samples contained greater than 0.3 ppm methyl nitrite, samples 3, 7, and 8. Sample 3, the cold start 505 segment from the VW with the noble metal catalyst, and sample 7, the sample taken over the entire four-bag FTP from the VW with the promoted base metal catalyst, were the only samples that were calculated to contain greater than 25 ppm HC (which is mostly methanol) and 25 ppm NO_x. Sample 8, the sample taken over the entire four-bag FTP from the Escort, contained greater than 0.3 ppm methyl nitrite only in the analyses conducted twelve or more hours after the sample was collected. These results are consistent with the previous findings reported in the literature, e.g., low levels of NO_x produce correspondingly low levels of methyl nitrite.

TABLE 14. METHYL NITRITE ANALYSES

Sample No.	Car	Fuel[a]	Catalyst	Sample Description[b]	Time at Analysis[c]	ppm Methyl Nitrite
1	VW	G	Noble	4-FTP	Initial	ND[d]
2	VW	M	Noble	4-FTP	Initial	ND
3	VW	M	Noble	FTP-Bag 1	Initial	1.1
4	VW	M	Noble	FTP-Bag 2	Initial	ND
5	VW	M	Noble	FTP-Bag 3	Initial	ND
6	VW	M	Noble	FTP-Bag 4	Initial	ND
7	VW	M	Promoted Base	4-FTP	Initial	4.1
8A	Escort	M	Noble	4-FTP	Initial	ND
8B	Escort	M	Noble	4-FTP	12 hours	0.5
8B	Escort	M	Noble	4-FTP	24 hours	0.3
8C	Escort	M	Noble	4-FTP	48 hours	0.5
9	Escort	M	Noble	HFET	Initial	ND

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[a] G = Gasoline and M = Methanol
[b] 4-FTP means a single bag taken over two UDDS cycles
[c] Initial analysis was conducted as soon as practical; this was about 30 minutes after sample collection.
[d] ND - not detected, detection limit ≈0.3 ppm

The data presented in Table 14 also indicate undetectable levels of methyl nitrite in the exhaust of the gasoline-fueled vehicle, which is again consistent with the reaction discussed above in that the gasoline vehicle exhaust contains no detectable levels of methanol. Also, it is observed from Table 14 that in comparing samples 3 through 6, the only bag where methyl nitrite appeared was bag 1. This is probably due to the fact that the VW emitted HC (methanol) during bag 1 but almost no HC during bags 2, 3, and 4. Also from Table 14, it is observed that the promoted base metal catalyst gave the highest levels of methyl nitrite observed. However, the promoted base metal catalyst tested was the one used for experimental diesel particulate traps and this one had very little catalyst surface area and therefore was not very efficient at NO_x or methanol control. This is probably the reason for the higher methyl nitrite results.

D. Mass Spectral Analysis

Two car configurations (the VW Rabbits, gasoline and methanol version) were operated over multiple UDDS driving schedules (as described in

Section II-F) to generate particulate for subsequent extraction and mass spectral analyses. At the same time, gaseous samples were collected on Tenax traps at a sampling point downstream of the particulate filter, and these samples were also analyzed by mass spectroscopy. The matrix of samples collected and analyzed is shown in Table 15.

TABLE 15. MASS SPECTRAL SAMPLING AND ANALYSES

	Samples Over Multiple UDDS Cycles		
	Gasoline Car	Methanol Car	Other Samples
20"x20" Pallflex Sample	2	2	-
Tenax Trap Sample	2	2	-
20"x20" Pallflex Blank	-	-	1
Extraction Solvent	-	-	1
Tenax Trap Blank	-	-	1
Tenax Trap Ambient	-	-	1

Both of the vehicles tested (VW gasoline and methanol) emitted very low levels of both HC and particulate, especially during warm operation. Consequently, sampling was difficult and resulted in only small amounts of sample for analysis. Nevertheless, the mass spectral data indicate, for the organic soluble fraction of the particulate, very few differences between the extracts from the gasoline- and the methanol-fueled vehicles. The majority of identifiable compounds (cellosolves, siloxanes, and phthalates) originated from the filter, from the ambient air in the laboratory and possibly from the engine oil. These high background levels, as compared to sample levels, prevented interpretation of the data. This was also the case with the gaseous samples obtained using Tenax traps. The majority of the compounds found on the sample traps were also found on an ambient air trap.

Analyses conditions, comparisons of scans, and sample chromatograms are presented in Appendix F.

E. Ames Bioassay Sampling and Results

Multiple UDDS cycles were run to generate particulate samples for subsequent extraction and Ames Bioassay analyses. Particulate samples were collected on four 500 mm x 500 mm (20 inch x 20 inch) Pallflex filters as described in Section II.J. The soluble organic fraction of the particulate was removed by soxhlet extraction procedures using methylene chloride as the extracting solvent. The soluble organic fraction was then sent to Microbiological Associates in Rockville, Maryland for Ames Bioassay analyses.

The Ames analyses were conducted in duplicate using tester strain TA98, both with and without metabolic activation. Table 16 lists the car configurations evaluated, the filter weight gain (on the four 20x20 filters), particulate emission rates based on the 20x20 filters, the extractable organic data, and the average Ames Bioassay results in revertants per microgram extract (rev/μg) and in revertants per kilometer driven (rev/km), both with and without metabolic activation. The complete Ames Bioassay results, as reported to Craig Harvey, EPA, Ann Arbor by Microbiological Associates, are included as Appendix G. The Ames activity values (rev/μg) reported in Table 16 are the average of the two duplicate mean model predicted slope values listed in the data in Appendix G.

The Indolene-fueled Escort and Rabbit, both with noble metal catalysts, had lower total particulate (1.68 and 1.65 mg/km) and higher percent organics (29 percent) than the remaining six configurations. The methanol-fueled Escort, with the promoted base metal catalyst, and the Escort fueled with Anafuel, with noble metal catalyst, had the highest total particulate (3.02 and 2.51 mg/km) and the lowest percent organics (17 and 18 percent) of the eight configurations evaluated. These differences in particulate and percent organics tended to cancel each other out, resulting in reasonably consistent extractable organic emissions from the eight configurations evaluated (0.29 to 0.55 mg/km).

The Ames activity for the eight samples ranged from 0.2 rev/μg (100 rev/km), without metabloic activation, for the Indolene-fueled Rabbit with noble metal catalyst to 13.7 rev/μg (6030 rev/km), with metabloic activation, for the Escort operating on Anafuel. All eight samples showed some toxicity to the TA98 tester strain and all eight gave higher activities with metabolic activation than without, indicating the presence of indirect acting mutagens in the samples.

Direct quantitative comparisons of Ames test results are not considered to be appropriate. However, it is of some interest to compare the results from this program to the results from a previous EPA program in which a 1980 VW Rabbit was evaluated with a variety of diesel fuels.(19) The Ames activities for those evaluations (also tester strain TA98) ranged from 3 to 24 rev/μg and from 113,000 to 1,206,000 rev/km. This is approximately double the rev/μg values and over 100 times greater than the rev/km values obtained in this program.

To our knowledge, the significance of differences in the magnitude of Ames results has not been defined. Therefore, the following discussion provides only relative comparisons of the data. The Ames results have been compared as to fuel and catalyst type and the following observations are presented.

- The methanol-fueled noble metal catalyst-equipped Rabbit gave higher Ames values than its gasoline-fueled counterpart, while the methanol-fueled Escort gave lower Ames values than its gasoline-fueled counterpart.

TABLE 16. AMES TEST RESULTS

			Particulate		Extractable Organics		Ames Activity TA98			
							Without Metabolic Activation		With Metabolic Activation	
Vehicle	Fuel	Catalyst	Sample Weight,mg	Vehicle Emission Rate,mg/km	Percent of Particulate	Vehicle Emission Rate,mg/km	rev/µg Extract	rev/km	rev/µg Extract	rev/km
Escort	Indolene	noble metal	161	1.68	29	0.48	2.6	1250	4.8	2300
Escort	Anafuel	noble metal	271	2.51	18	0.44	12.2	5370	13.7	6030
Escort	Methanol	noble metal	198	1.83	26	0.47	0.5	240	0.7	330
Escort	Methanol	base metal[a]	326	3.02	17	0.50	0.6	300	1.3	650
Escort	Methanol	none	199	1.84	28	0.52	2.3	1200	4.0	2080
VW	Indolene	noble metal	177	1.64	29	0.48	0.2	100	0.8	380
VW	Methanol	noble metal	227	2.10	26	0.55	2.7	1490	4.1	2260
VW	Methanol	base metal[a]	NA[b]	NA	NA	0.29	0.4	120	3.3	960

[a] Promoted base metal catalyst - includes palladium

[b] NA - Data Not Available

- Opposing results were also observed when comparing the Ames activities from noble and promoted base metal catalyst equipped cars. The Escort, equipped with the noble metal catalyst, gave slightly lower Ames values than when equipped with the promoted base metal catalyst, while the Rabbit gave lower Ames values when equipped with the promoted base metal catalyst than when equipped with the noble metal catalyst.
- The methanol-fueled Escort without a catalyst gave higher Ames activity than when equipped with either a noble metal catalyst or a promoted base metal catalyst.
- The Escort gave higher Ames values when fueled with Anafuel than when fueled with Indolene.

F. Other Testing

A fuel mixture of 94.5% methanol and 5.5% isopentane is reportedly being used in the methanol-fueled vehicles being tested in California. The isopentane is added to improve the cold-start capabilities at low ambient temperatures. These low ambient temperatures, at which starting becomes a problem, are considerably lower than the temperatures maintained within this laboratory for FTP testing. Therefore, addition of isopentane was not necessary for starting purposes in the evaluations conducted. It is not known if isopentane would be the best volatility enhancer to use in a commercial methanol. Other compounds such as a methyl-t-butylether (MTBE) or a low boiling gasoline cut may be more effective and/or less costly.

To determine the effects of a methanol-isopentane blend on driveability and emission rates, the Ford Escort (with the original equipment catalyst and carburetor) was evaluated over a single 3-bag FTP, using a mixture of 94.5% methanol and 5.5% isopentane. The results of this test are given in Table 17, along with the emission results obtained with this car fueled with pure methanol. The computer printout for this test is included in Appendix E-1.

There was no apparent change in the driveability (evaluated on a subjective basis) of the Escort with the methanol-isopentane blend, and the CO and NO_x emission rates were similar to those obtained with pure methanol. The HC emission rates were higher with this blend in all three cycles of the FTP. The car had not been started within the previous four days before the FTP test was run; this could have affected the HC and CO emissions in the cold-start 505. The emissions in the other two cycles, however, should not have been affected.

TABLE 17. EFFECT OF METHANOL-ISOPENTANE BLEND WITH CAR 83
1981 Methanol-Fueled Ford Escort

	Composite FTP g/km			
	Pure Methanol			Methanol/isopentane Blend
	Low	High	Average	
HC	0.25	0.27	0.26	0.46*
CO	3.24	4.51	3.75	4.30*
NO_x	0.23	0.26	0.25	0.23
	Cold-Start 505, g/km			
HC	0.63	0.78	0.69	1.24*
CO	4.06	4.65	4.33	6.59*
NO_x	0.51	0.65	0.56	0.54
	Cold-Start 867, g/km			
HC	0.10	0.14	0.11	0.22
CO	2.98	4.26	3.43	3.82
NO_x	0.10	0.14	0.12	0.11
	Hot-Start 505, g/km			
HC	0.21	0.25	0.22	0.31
CO	2.80	5.31	3.91	3.47
NO_x	0.22	0.28	0.24	0.23

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*Car was not operated for four days prior to the cold-start 505.

V. ANALYSES OF THE RESULTS

This section reports the analyses performed on the emissions data generated in this program. The analyses involved averaging and reformatting the data to enable making various comparisons. Due to the very limited number of data points for each constituent at each specific condition, advanced statistical analyses were judged to be inapplicable. Several comparisons, that are discussed in this section, include: emissions from the methanol-fueled automobiles tested to emissions from the gasoline-fueled automobiles tested; emissions from methanol-fueled automobiles tested with factory-equipped noble metal catalysts to emissions from methanol-fueled automobiles tested with promoted base metal catalysts; emissions from the Ford Escort using Indolene fuel to the emissions from the same car using Anafuel; and emissions from catalyst-equipped methanol-fueled automobiles tested to emissions from methanol-fueled automobiles tested with the catalyst removed. Other discussions in this section include the measurement of total hydrocarbon and formaldehyde emissions from methanol-fueled automobiles.

A. Emissions from Automobiles Operating on Methanol and Gasoline

In this program, regulated and unregulated emissions were evaluated from two 1981 model year methanol-fueled automobiles, a Ford Escort and a Volkswagen Rabbit, and from two 1981 gasoline-fueled automobiles, also a Ford Escort and a Volkswagen Rabbit. Each of the four automobiles were evaluated in triplicate with each fuel. A summary of the average FTP emissions, fuel consumption and energy consumption data for the four automobiles is presented in Table 18.

As expected, the methanol-fueled Escort and Rabbit consumed nearly twice the volume of fuel consumed by their gasoline-fueled counterparts. This higher fuel consumption is due to the lower average energy density of methanol. However, on an energy basis the methanol-fueled cars consumed slightly less energy than their gasoline counterparts. These values are calculated using the energy content of gasoline (113,300 BTU/gal) and methanol (56,123 BTU/gal).(20) Several other findings of interest, as noted in the data in Table 18, are as follows:

- In the methanol-fueled cars, the hydrocarbon emissions were composed primarily of unburned methanol fuel.
- Particulate emissions were higher for the gasoline-fueled cars.
- Formaldehyde emissions were considerably higher for methanol-fueled cars, 21 and 6 mg/km, than for the gasoline-fueled cars, <1 and 0 mg/km.

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TABLE 18. SUMMARY OF THE FTP RESULTS FOR CAR CONFIGURATIONS 81, 83, 84 AND 85

	Emissions in mg/km, except as noted			
	Ford Escorts		VW Rabbits	
Car Configuration No.	81	83	85	84
Fuel	Gasoline	Methanol	Gasoline	Methanol
Hydrocarbons, g/km	0.23	0.26[a]	0.07	0.24[a]
Carbon Monoxide, g/km	2.79	3.75	0.67	0.55
Oxides of Nitrogen, g/km	0.34	0.25	0.10	0.42
Fuel Cons., ℓ/100 km	9.6	18.7	9.9	17.0
Energy Cons., 10^6J/km	3.03	2.92	3.12	2.66
Total Particulate	6	4	7	3
Methanol	0	253	0	272
Ethanol	0	0	0	0
Nitrosamines	0.000	0.000	0.000	0.000
Formaldehyde	0.1	20.5	0.0	6.4
Methane	59.7	30.0	8.7	3.0
Ethylene	5.4	0.2	3.0	<0.1
Ethane	11.3	0.3	1.6	<0.1
Acetylene	0.9	<0.1	1.1	0.1
Propane	0.5	0.4	0.0	0.0
Propylene	3.8	0.0	2.6	0.0
Benzene	4.0	<0.1	3.3	0.0
Toluene	10.7	0.1	5.7	0.0
Ammonia	b	6	b	b
Total Cyanide	b	0.00	b	b
Organic Amines	b	0.01	b	b

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[a] Measured HC expressed as methanol
[b] Not measured

- Individual hydrocarbon emissions (methane, ethane, ethylene, acetylene, propane, propylene, benzene and toluene) were higher from gasoline-fueled cars.

- The total of the individual hydrocarbons measured in this program comprised only a small portion of the total HC for the methanol-fueled cars, up to ten percent; whereas the total individual hydrocarbons constituted thirty to forty percent of the total HC for the gasoline-fueled cars.

- The ammonia, cyanide, and organic amine emissions from the one car evaluated (6 mg/km, 0.0 mg/km, and 0.01 mg/km, respectively) were similar to or lower than the average emissions from three-way catalyst equipped gasoline-fueled automobiles tested in a previous project(4) (8 mg/km, 1.8 mg/km, and 0.03 mg/km, respectively).

- No nitrosamines were detected in the exhaust or either the methanol- or gasoline-fueled automobiles.

The major differences between the results with the methanol-fueled and the gasoline-fueled automobiles were the higher fuel consumption with the methanol-fueled automobiles. However, the methanol-fueled vehicles consumed slightly less energy. There were major differences in the composition of the hydrocarbon emissions.

B. Emissions from Automobiles with Noble Metal and Promoted Base Metal Catalysts

Regulated and unregulated exhaust emissions and fuel consumption were also evaluated for the methanol-fueled Ford Escort and Volkswagen Rabbit equipped with promoted base metal catalysts. A summary of the average FTP emissions and fuel consumption data for these evaluations, along with the corresponding noble metal evaluations, is given in Table 19.

Referring to the data in Table 19, most emissions decreased when the noble metal catalyst on the Ford Escort was replaced with a promoted base metal catalyst. With the VW Rabbit, however, the emissions increased when the noble metal catalyst was replaced with the W. R. Grace promoted base metal catalyst. It is uncertain why the evaluations produced opposing results; however, it may be of importance that the two automobiles utilized different catalyst configurations. The Ford Escort utilized a dual-bed catalytic converter (a 3-way catalyst followed by air injection and an oxidation catalyst) for its factory supplied catalyst; whereas, the VW Rabbit utilized a single-unit three-way catalyst. These same configurations were reproduced for the promoted base metal catalyst evaluations, except the Ford used twice the amount of catalyst.

TABLE 19. SUMMARY OF THE FTP RESULTS FOR CAR CONFIGURATIONS 83, 84, 87, and 89

	Emissions in mg/km, except at noted			
	Ford Escort		VW Rabbit	
Car Conf. No.	83	87	84	89
Catalyst	Noble Metal	Promoted Base Metal	Noble Metal	Promoted Base Metal
Hydrocarbons*, g/km	0.26	0.19	0.24	0.30
Carbon Monoxide, g/km	3.75	0.94	0.55	1.70
Oxides of Nitrogen, g/km	0.25	0.22	0.42	0.94
Fuel Cons., ℓ/100/km	18.7	18.5	17.0	16.9
Energy Cons., 10^6J/km	2.92	2.89	2.66	2.64
Total Particulates	4	2	3	4
Methanol	253	94	272	336
Ethanol	0	0	0	0
Nitrosamines	0.000	0.000	0.000	0.000
Formaldehyde	21	2	6	20
Methane	30	22	3	7

*Measured HC expressed as methanol

C. Emissions from Methanol-Fueled Automobiles With and Without Catalytic Aftertreatment

The methanol-fueled Escort was evaluated without catalytic aftertreatment to permit a comparison of the emissions to those from this same car with catalytic aftertreatment. This would also give an indication of the repeatability of the engine-out emissions since two FTP's were run. Table 20 gives the average FTP results for evaluations of the Ford Escort without catalytic aftertreatment, and with a noble metal catalyst, and with a promoted base metal catalyst.

Referring to the data in Table 20, the promoted base metal and noble metal catalysts significatnly reduced (85-100 percent reduction) HC, CO, methanol, formaldehyde, and organic amine emissions relative to the values without a catalyst. Emissions that were reduced 30-65 percent with the use of catalytic aftertreatment include NO_x, methane, and particulate.

To provide additional information, the VW Rabbit was also evaluated over a single FTP test cycle without catalytic aftertreatment. The computer printout for this test is included in Appendix E-2. The regulated FTP emissions and the fuel consumption for this test, and for the VW Rabbit with noble metal and promoted base metal catalytic aftertreatment, are summarized on the following page.

TABLE 20. FTP EVALUATIONS OF THE METHANOL-FUELED FORD ESCORT

	Emissions in mg/km, except as noted		
Car Configuration No.	83	87	88
Catalyst	Noble Metal	Promoted Base Metal	No Catalyst
Hydrocarbons*, g/km	0.26	0.19	6.39
Carbon Monoxide, g/km	3.75	0.94	25.34
Oxides of Nitrogen, g/km	0.25	0.22	0.38
Fuel Cons., ℓ/100 km	18.7	18.5	19.1
Total Particulates	4	2	7
Methanol	253	94	7126
Formaldehyde	21	2	221
Methane	30	22	41
Ammonia	6	3	2
Cyanide	0.0	0.1	0.1
Amines	0.0	0.0	0.4
Number of FTP's	3	3	2

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*Measured HC expressed as methanol

FTP Results for VW Rabbit

Car Conf. No.	84	89[a]	--[b]
Catalyst	Noble Metal	Promoted Base Metal	No Catalyst
HC, g/km[c]	0.24	0.30	1.29
CO, g/km	0.55	1.70	4.67
NO_x, g/km	0.42	0.94	1.16
Fuel Cons., ℓ/100 km	17.0	16.9	16.7

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[a] Vehicle was tested with a promoted base metal catalyst volume approximately equal to the noble metal catalyst volume it replaced.

[b] Single evaluation, no car configuration number was assigned.

[c] Measured HC expressed as methanol

With the VW Rabbit, the noble metal catalyst appeared to be significantly more efficient in reducing the regulated emissions than did the promoted base metal catalyst. Hydrocarbons, carbon monoxide, and oxides of nitrogen were reduced 81, 88, and 64 percent, respectively, when using the noble metal catalyst and 77, 64, and 19 percent, respectively, when using the promoted base metal catalyst.

D. Emissions from the Ford Escort Fueled with Gasoline and Anafuel

The 1981 model year gasoline-fueled Ford Escort was also evaluated with Anafuel, a proprietary alcohol-gasoline blend. A summary of the results of these evaluations, along with the results obtained with gasoline (Indolene), is presented in Table 21.

TABLE 21. EMISSIONS AND FUEL CONSUMPTION RESULTS FOR THE GASOLINE-FUELED FORD ESCORT

	Emissions in mg/km, except as noted			
	FTP		HFET	
	Indolene	Anafuel	Indolene	Anafuel
Hydrocarbon, g/km	0.23	0.19[a]	0.10	0.05[a]
Carbon Monoxide, g/km	2.79	2.02	1.05	0.60
Oxides of Nitrogen, g/km	0.34	0.42	0.31	0.42
Particulates, mg/km	6	4	1	1
Methanol, mg/km	0	0	0	0
Ethanol, mg/km	0	0	0	0
Formaldehyde, mg/km	0.1	0.4	0.0	0.0
Nitrosamines, mg/km	0.000	0.000	b	b
Individual Hydrocarbons	97	75	47	22
Percent IHC of HC	42%	39%	47%	44%
Fuel Cons., ℓ/100 km	9.6	9.6	6.2	6.3

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[a] Measured hydrocarbons expressed as Anafuel

[b] Analyses not conducted

With the Anafuel, relative to results with Indolene, HC and CO emissions decreased (primarily in the HFET), NO_x increased, and fuel consumption remained essentially the same. Particulate emissions were somewhat lower with Anafuel than with Indolene. Based on results in previous projects, the 6 mg/km for the FTP with Indolene is within the expected range. Emissions of methanol, ethanol, and aldehydes and ketones were either zero or sufficiently low to be considered negligible. The individual hydrocarbon emissions were 39 to 47 percent of the total hydrocarbon emissions.

In the HFET evaluations, there were relatively large variations of CO with both fuels and of NO_x and particulates with the Anafuel. Due to these variations in emissions with the Anafuel, a fourth HFET test was run. The results are summarized on the following page.

	HFET with Anafuel			
	821	822	823	824
HC, g/km	0.06	0.04	0.05	0.05
CO, g/km	0.80	0.31	0.69	0.51
NO_x, g/km	0.38	0.55	0.32	0.50
Fuel Cons., ℓ/100 km	6.5	6.2	6.2	6.2
Particulate, mg/km	1.1	1.2	0.5	0.5

The fourth test essentially verified the reality of the variability that was experienced in the first three. Reasons for this variability are not known, but in most cases the absolute values of the variations were small.

Although the Anafuel contained a significant amount of methanol, the fuel consumption with Anafuel was essentially the same as it was with Indolene. It should also be noted that there was no apparent change in driveability (evaluated on subjective basis) with the Anafuel relative to Indolene. This is based on the subjective judgement of three different drivers, plus analyses of the driver traces.

The hydrocarbon portion of the Anafuel has essentially the same weight percentages of hydrogen and carbon and the same hydrogen to carbon ratio as did the Indolene (based on the Anafuel composition, obtained from the EPA). Theoretically, on an equal BTU basis, the volumetric fuel consumption with Anafuel should have been two to three percent higher than with Indolene. Such a small difference, however, is within the repeatability of the fuel consumption determinations in the emissions cycles. The fuel composition and parameters that were used are summarized as follows:

	Specific Gravity	Carbon % of:		HC% of Fuel	g/gallon			
		Fuel	HC		C	H	O	Fuel
Indolene	0.739	86.6	86.6	100	2421	375	0	2796
Anafuel	0.773	81.9	86.7	94.4	2395	366	165	2926

E. Summary of Formaldehyde Emissions

Since formaldehyde is the most prevalent aldehyde in exhaust and is a suspected carcinogen, additional comparisons have been made and reported. Table 22 lists the formaldehyde emissions from automobiles tested in this project, along with the values from automobiles tested in previous EPA projects. The formaldehyde emissions from the methanol-fueled cars with catalytic aftertreatment were as follows: almost equivalent to the emission rates from the one non-catalyst 1977 model year gasoline-fueled automobile; two to six times higher than the emissions from oxidation-catalyst equipped 1978 model year gasoline-fueled automobiles; and ten times higher than the emissions from the three-way catalyst equipped 1978 and 1979 model year gasoline-fueled automobiles. The formaldehyde emissions from the methanol-fueled Escort without catalytic aftertreatment were seven times higher than the formaldehyde emissions from unmodified 1970 model year gasoline-fueled non-catalyst automobiles, and similar to the maximum emissions from malfunctioning 1970 model year automobiles.

TABLE 22. COMPARISON OF AVERAGE FTP FORMALDEHYDE EMISSIONS

	Formaldehyde Emissions, mg/km
Methanol-Fueled	
Catalytic Aftertreatment[a]	12
No Catalytic Aftertreatment[a]	221
Gasoline-Fueled	
1981 Low Mileage Cars/3-Way Catalysts[a]	<1
1978 & 1979 3-Way Catalyst Equipped Cars[b]	1
1978 Oxidation Catalyst Equipped Cars[c]	2-7
1977 Non-Catalyst Car[d]	10
1970 Non-Catalyst Cars[e]	32
Maximum for Malfunctioning Car[f]	206

---

[a] Data from this program, catalytic aftertreatment includes both noble-metal and base-metal data.

[b] Average for low mileage 1978 and 1979 three-way catalyst-equipped cars in unmodified configuration, EPA Contract 68-03-2692(2,3) and for high mileage 1978 and 1979 three-way catalyst equipped cars, before and after tune-up, EPA Contract 68-03-2884, Task Specifications 7 and 10.(6)

[c] Average for low mileage 1978 oxidation catalyst-equipped cars in unmodified configuration, EPA Contract 68-03-2499(1) and for high mileage 1978 oxidation catalyst-equipped cars, before and after tune-up, EPA Contract 68-03-2884, Task Specifications 7 and 10.

[d] Value from one 1977 non-catalyst car in unmodified configuration, EPA Contract 68-03-2499.(1)

[e] Average for four 1970 non-catalyst cars, in unmodified configuration, EPA Contract 68-03-2884, Task Specifications 4 and 5.(5)

[f] Highest value for 1970 non-catalyst car, in malfunction configuration, EPA Contract 68-03-2884, Task Specifications 4 and 5.

F. Hydrocarbon Emissions from Methanol-Fueled Automobiles

In this program, the reported hydrocarbon emissions for all fuels evaluated, including the non-standard hydrocarbon fuels (methanol or Anafuel), are the FID-measured values expressed as the fuel used (i.e., the reported hydrocarbon emissions included the weight of the oxygen in the fuel). While the hydrocarbon emissions have been corrected for oxygen content, no correction has been applied to the FID response. The magnitude of the FID response differs for different types of hydrocarbon compounds. The relative response of methanol as compared to propane (the hydrocarbon commonly used to calibrate the FID response) has been found in the literature to range from 0.73 to 0.85.(21,22,23,24)

Using the data in this program, the FID response factor for methanol has been calculated to be no larger than 0.89. This value has been calculated using the measured methanol, individual hydrocarbons (IHC), and total hydrocarbon emissions for Car Configurations 83, 84, 86, 88, and 89 (Table 23), along with a response factor of one for the individual hydrocarbons. These car configurations utilized in the calculations all used methanol fuel. Car Configurations 87 and 90 also used methanol. Car 87, however, was omitted due to the unusually low methanol emissions, and Car 90 was omitted due to the absence of individual hydrocarbon emission data. Formaldehyde emissions were not used in these calculations, due to the low response factor for formaldehyde (estimated to be less than 0.1) and its relatively low emission rate in the exhaust. The contribution of formaldehyde to the total hydrocarbon response of the FID is estimated to be on the order of 1 percent.

TABLE 23. CALCULATED HYDROCARBON EMISSIONS RATES

	Methanol[a]	IHC[b]	Measured FID HC[c]	Calculated HC[d]
Car Conf. 83	0.253	0.031	0.26	0.26
Car Conf. 84	0.273	0.003	0.24	0.25
Car Conf. 86	0.573	0.010	0.54	0.52
Car Conf. 88	7.126	0.048	6.39	6.39
Car Conf. 89	0.336	0.010	0.30	0.31

---

[a] Collected in water and analyzed using a GC-FID.

[b] Collected in a bag and analyzed using a GC-FID; includes methane, ethylene, ethane, acetylene, propane, propylene, benzene and toluene.

[c] Collected in a bag and analyzed using an FID.

[d] Calculated value is based on a 0.89 response factor for methanol and a response factor of 1.0 for the measured IHC compounds.

As can be seen from the data in Table 23, a 0.89 FID response factor for methanol results in a calculated HC that is in good agreement with the HC as measured by FID. However, the measured individual hydrocarbons do not include all the hydrocarbons present in the exhaust. Therefore, the actual FID response factor for methanol would be lower than 0.89, and would probably be within the range of 0.73 to 0.85 reported in the literature.

These calculations indicate that the values measured in this program are reasonably consistent with relationships reported in the literature. They also illustrate that the use of response factors requires a breakdown of the total hydrocarbon compounds present in the exhaust. A valid question, however, is the relative importance of methanol as a pollutant relative to the other hydrocarbons normally emitted. This question has not been addressed in this program.

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APPENDICES

- A - GENERAL INFORMATION
- B - INDIVIDUAL AND AVERAGE TEST RESULTS SUMMARY TABLES
- C - FTP INDIVIDUAL SAMPLE RESULTS
- D - COMPUTER PRINTOUTS OF THE REGULATED EMISSIONS TEST RESULTS
- E - ADDITIONAL TEST RESULTS
- F - MASS SPECTRAL RESULTS
- G - AMES TESTS RESULTS

APPENDIX A

GENERAL INFORMATION

A-1 Description of Base Metal Catalyst for Methanol-Fueled Ford Escort
A-2 Description of Base Metal Catalyst for Methanol-Fueled Volkswagen Rabbit
A-3 Calculations for Unregulated Emissions
A-4 The Measurement of Methanol in Exhaust

APPENDIX A-1

DESCRIPTION OF BASE METAL CATALYST FOR METHANOL-FUELED FORD ESCORT

Base metal catalyst substrates, for use on the methanol-fueled Ford Escort, were provided by Davison Chemical, a division of W.R. Grace. Four each 68mm by 144mm eliptical by 72mm long (2.68" x 5.68" x 2.82") ceramic monoliths with Davex 908 catalyst were provided, and these were identified as SMR 14-1513. These substrates had cells 1.27 millimeters square (twenty square cells per square inch). It was reported by a representative of W.R. Grace that these catalyst substrates have 71 square inches of surface area per cubic inch of substrate (about 28 square centimeters per cubic centimeter).

After being informed that the Ford Escort utilized a duel-bed catalytic converter (3-way catalyst followed by air injection and an oxidation catalyst), the representative from W.R. Grace recommended that two of the substrates be used prior to the air injection, and the other two subsequent to air injection. This was discussed with the EPA Project Officer, who subsequently relayed a decision to package the catalyst in that manner. Other discussion involved the possibility that the 3-way section was not being utilized as a 3-way catalyst on this methanol-fueled car.

The substrates were packaged into a stainless steel container fabricated for this purpose. A gasket, one-eighth of an inch thick, was installed between the substrates to assure against blockage of the cell openings. A gap of approximately one inch was provided between the sections of substrate where the air injection tube was located. Ceramic insulation was used between the eliptical outside diameter of the substrates and the container.

Exhaust tubing was added to both ends of this catalytic converter up to existing connections in the exhaust system. In this manner, the original exhaust system was just disconnected, and did not require modification. The only modification to the original exhaust system was the installation of a probe to enable measurement of exhaust backpressure.

APPENDIX A-2

DESCRIPTION OF BASE METAL CATALYST FOR METHANOL-FUELED VOLKSWAGEN RABBIT

A base metal catalyst substrate, for use on the Volkswagen Rabbit, was provided by Davison Chemical, a division of W.R. Grace. One 102mm diameter by 152mm long (4" x 6") unit (Grade 6) with 908 catalyst was provided, and this unit was identified as SMR 14-1526. This substrate was an open-cell ceramic foam having spherical cells that were nominally three millimeters in diameter.

A representative of W.R. Grace subsequently reported that this catalyst substrate has approximately 5 to 6 square inches of surface area per cubic inch of substrate (about 2 square centimeters per cubic centimeter). Based on this reported surface area, this catalyst had only about one-thirteenth the total surface area of the original equipment catalytic converter that was on the Volkswagen.

This substrate was installed into a container that was fabricated for this purpose. Ceramic insulation was utilized in the assembly of the substrate into the container.

APPENDIX A-3. CALCULATIONS FOR UNREGULATED EMISSIONS

This appendix documents the calculational methods used for the unregulated emissions. All values not defined (i.e., CVS FLOW, VOL, etc.) are obtained from the computer printouts for the regulated emissions. Example printout is included as Table 1.

A. Individual Hydrocarbons and Ethanol

1. For FTP Evaluations only, convert 2-Bag UDDS to Equivalent 1-Bag UDDS

$$\text{PPM 12} = \frac{\text{PPM}_1 \times \text{CVS FLOW}_1 + \text{PPM}_2 \times \text{CVS FLOW}_2}{\text{CVS FLOW}_1 + \text{CVS FLOW}_2}$$

$$\text{PPM 34} = \frac{\text{PPM}_3 \times \text{CVS FLOW}_3 + \text{PPM}_4 \times \text{CVS FLOW}_4}{\text{CVS FLOW}_3 + \text{PPM FLOW}_4}$$

2. Convert PPM to $\mu g/m^3$:

$$\mu g/m^3 = 35.32 \times \text{DENSITY} \times \text{PPM}$$

Density, g/ft^3			
Methane CH_4	- 18.86	Propane C_3H_8	- 17.29
Ethylene C_2H_4	- 16.50	Propylene C_3H_6	- 16.50
Ethane C_2H_6	- 17.68	Benzene C_6H_6	- 15.33
Acetylene C_2H_2	- 15.33	Toluene C_7H_8	- 15.49
		Ethanol C_2H_5OH	- 54.26

B. Calculation of mg/km

$$\text{mg/km} = [(\text{EXH} \times \text{SCF} - \text{BG} \times \text{DFC}) \times \text{VOL} \div \text{KM}] \div 1000$$

Calculations were performed using a Hewlett-Packard HP-65 Programmable Calculator.

Dry (DVC) and (SFC) were used for all unregulated emissions except IHC and Ethanol

DFC and SFC are obtained from the computer print-out for regulated emissions. (See Tables 1 and 2).

C. Calculation for 4-FTP (Aldehydes, Methanol, Ethanol, Individual Hydrocarbons, and Particulates)

$$\text{Composite 4-FTP} = 0.43 \times (\text{Value for 1 \& 2}) + 0.57 \times (\text{Value for 3 \& 4})$$

Only one sample was taken over the entire 4-Bag FTP for nitrosamines, ammonia, total cyanide, and organic amines, therefore, calculations were performed as in B.

APPENDIX A-3 (Cont'd). CALCULATIONS FOR UNREGULATED EMISSIONS

TABLE 1. COMPUTER PRINTOUT NOMENCLATURE FOR FOUR-BAG FTP

```
                                   FTP   - VEHICLE EMISSIONS RESULTS
                                              PROJECT

TEST NO.            RUN                          VEHICLE NO.                        TEST WEIGHT        KG(       LBS)
VEHICLE MODEL                                    DATE                               ACTUAL ROAD LOAD       KW(       HP)
ENGINE                                           BAG CART NO.   / CVS NO.           GASOLINE
TRANSMISSION                                     DYNO NO.                           ODOMETER         KM(        MILES)

BAROMETER          MM HG(        IN HG)          DRY BULB TEMP.      DEG C(      DEG F)
RELATIVE HUMIDITY       PCT                      ABS. HUMIDITY      GM/KG           NOX HUMIDITY CORRECTION FACTOR
BAG RESULTS
   BAG NUMBER                                          1                  2                   3                   4
   DESCRIPTION                                  COLD TRANSIENT       STABILIZED         HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)
   BLOWER INLET P MM. H2O(IN. H2O)
   BLOWER INLET TEMP. DEG. C(DEG. F)
   BLOWER REVOLUTIONS
   TOT FLOW STD. CU. METRES(SCF)
   HC  SAMPLE METER/RANGE/PPM
   HC  BCKGRD METER/RANGE/PPM
   CO  SAMPLE METER/RANGE/PPM
   CO  BCKGRD METER/RANGE/PPM
   CO2 SAMPLE METER/RANGE/PCT
   CO2 BCKGRD METER/RANGE/PCT
   NOX SAMPLE METER/RANGE/PPM
   NOX BCKGRD METER/RANGE/PPM
   DILUTION FACTOR
   HC  CONCENTRATION PPM
   CO  CONCENTRATION PPM
   CO2 CONCENTRATION PCT
   NOX CONCENTRATION PPM
   HC  MASS GRAMS
   CO  MASS GRAMS
   CO2 MASS GRAMS
   NOX MASS GRAMS

   HC  GRAMS/KM
   CO  GRAMS/KM
   CO2 GRAMS/KM
   NOX GRAMS/KM
   FUEL CONSUMPTION BY CB L/100KM

   RUN TIME              SECONDS
   MEASURED DISTANCE     KM
   SCF, DRY
        DFC, WET (DRY)
        TOT VOL (SCM) / SAM BLR (SCM)
        KM  (MEASURED)
        FUEL CONSUMPTION L/100KM

COMPOSITE RESULTS                                                                                  3-BAG      (4-BAG)
   TEST NUMBER                                                          CARBON DIOXIDE      G/KM              (       )
   BAROMETER     MM HG                                                  FUEL CONSUMPTION    L/100KM           (       )
   HUMIDITY      G/KG                                                   HYDROCARBONS (THC)  G/KM              (       )
   TEMPERATURE   DEG C                                                  CARBON MONOXIDE     G/KM              (       )
                                                                        OXIDES OF NITROGEN  G/KM              (       )
```

APPENDIX A-3 (CONT'D). CALCULATION FOR UNREGULATED EMISSIONS
TABLE 2. DEFINITION OF COMPUTER PRINTOUT NOMENCLATURE

FOR FOUR-BAG AND SINGLE-BAG

REGULATED EMISSIONS

The following are primarily exerpts taken from the computer program:

```
C    DFC = DILUTION FACTOR CORRECTION  DFC = FOR WET SAMPLES  DFCD = FOR DRY

     DF(J)=13.4/(  YC2(2,J) +(( YH(2,J) + CC(2,J))/10000.))
     DFC(J) = 1 - 1/DF(J)

C    CALCULATE DFC, VOL. KM FOR BAGS 1+2 AND 3+4
C    DF = TOTAL CVS FLOW / EXHAUST FLOW = AIR + EXH / EXH
C    DFC = 1 - 1/DF = 1 - EXH/(AIR+EXH) = AIR/(AIR+EXH)
     DFC12 =(DFC(1)*VMIX(1) + DFC(2)*VMIX(2)) / (VMIX(1) + VMIX(2))
     DFC34 = (DFC(3)*VMIX(3) + DFC(4)*VMIX(4)) / (VMIX(3) + VMIX(4))
     IF(RH.LT.20) RH = 20
     DFCD12 = DFC12 * (1.0 - 0.000323*(RH - 20))
     DFCD34 = DFC34 * (1.0 - 0.000323*(RH - 20))

C    SCF = SAMPLE CORRECTION FACTOR FOR WATER REMOVAL   SCF = FOR WET  SCFD=DRY
     SCF12 = 1.000
     SCF34 = 1.000
     SCFD12 = (SCFD(1)*VMIX(1)+SCFD(2)+VMIX(2)) / (VMIX(1) + VMIX(2))
     SCFD34 = (SCFD(3)*VMIX(3)+SCFD(4)*VMIX(4)) / (VMIX(3) + VMIX(4))


C    CALCULATE 4-BAG EMISSIONS AND FUEL CONSUMPTION
C    4-BAG = 0.43*(BAG1+BAG2)/(MILES1+MILES2)+0.57*(BAG3+BAG4)/(MILES3+MILES4)

     DISTA=MILES(1) + MILES(2)
     DISTB=MILES(2) + MILES(3)
     DISTC=MILES(3) + MILES(4)

     HCWM4 = 0.43*((HCM(1)+HCM(2)) / DISTA) + 0.57*((HCM(3)+HCM(4)) / DISTC)
     COWM4 = 0.43*((COM(1)+COM(2)) / DISTA) + 0.57*((COM(3)+COM(4)) / DISTC)
     CO2WM4= 0.43*((CO2M(1)+CO2M(2))/DISTA) + 0.57*((CO2M(3)+CO2M(4)) / DISTC)
     NOXWM4= 0.43*((NOXM(1)+NOXM(2))/DISTA) + 0.57*((NOXM(3)+NOXM(4)) / DISTC)
     CBFE4 = 2421. / (.866*HCWM4 + .429*COWM4 + .273*CO2WM4)
```

APPENDIX A-4

THE MEASUREMENT OF METHANOL IN EXHAUST

The measurement of methanol in exhaust is accomplished by bubbling the exhaust through glass impingers containing deionized water. The exhaust sample is collected continuously during the test cycle. For analysis, a portion of the aqueous solution is injected into a gas chromatograph equipped with a flame ionization detector (FID). External methanol standards in deionized water are used to quantify the results. Detection limits for this procedure are on the order of 0.06 ppm in dilute exhaust.

SAMPLING SYSTEM

Two glass impingers in series, with each containing 25 mℓ of deionized water are used to collect exhaust samples for the analysis of methanol. A flow schematic of the sample collection system is shown in Figure 1. The two glass impingers collect 99 percent of the methanol in exhaust. The temperature of the impinger is maintained at 0-5°C by an ice water bath, and the flow rate through the impinger is maintained at 4ℓ/minute by the sample pump. A dry gas meter is used to determine the total flow through the impinger during a given sampling period. The temperature of the gas stream is monitored by a thermocouple immediately prior to the dry gas meter. A drier is included in the system to prevent condensation in the pump, flowmeter, dry gas meter, etc. The flowmeter in the system allows continuous monitoring of the sample flow to insure proper flow rates during the sampling. Several views of the sampling system are shown in Figure 2.

ANALYTICAL PROCEDURE

The analysis of methanol is accomplished by collecting methanol in deionized water and analyzing the sample with a gas chromatograph equipped with an FID. The analysis flow schematic for methanol is shown in Figure 3. A detailed description of the procedure follows.

For the analysis of methanol, dilute exhaust is bubbled through two glass impingers each containing 25 mℓ of deionized water. Upon completion of each driving cycle, the impinger is removed and the contents are transferred to a 30 mℓ polypropylene bottle, and capped.

A Perkin-Elmer 3920B gas chromatograph equipped with a flame ionization detector is used to analyze the sample. A 5 μℓ portion of the sample is injected into the gas chromatograph (GC). The column is a 3' X 1/8" Teflon column containing 120/150 mesh Porapak Q. The carrier gas is helium which flows through the column at a rate of 20 mℓ/minute. The column temperature is maintained at 100°C. A chromatogram of a standard sample containing 63 ppm methanol is shown in Figure 4. To

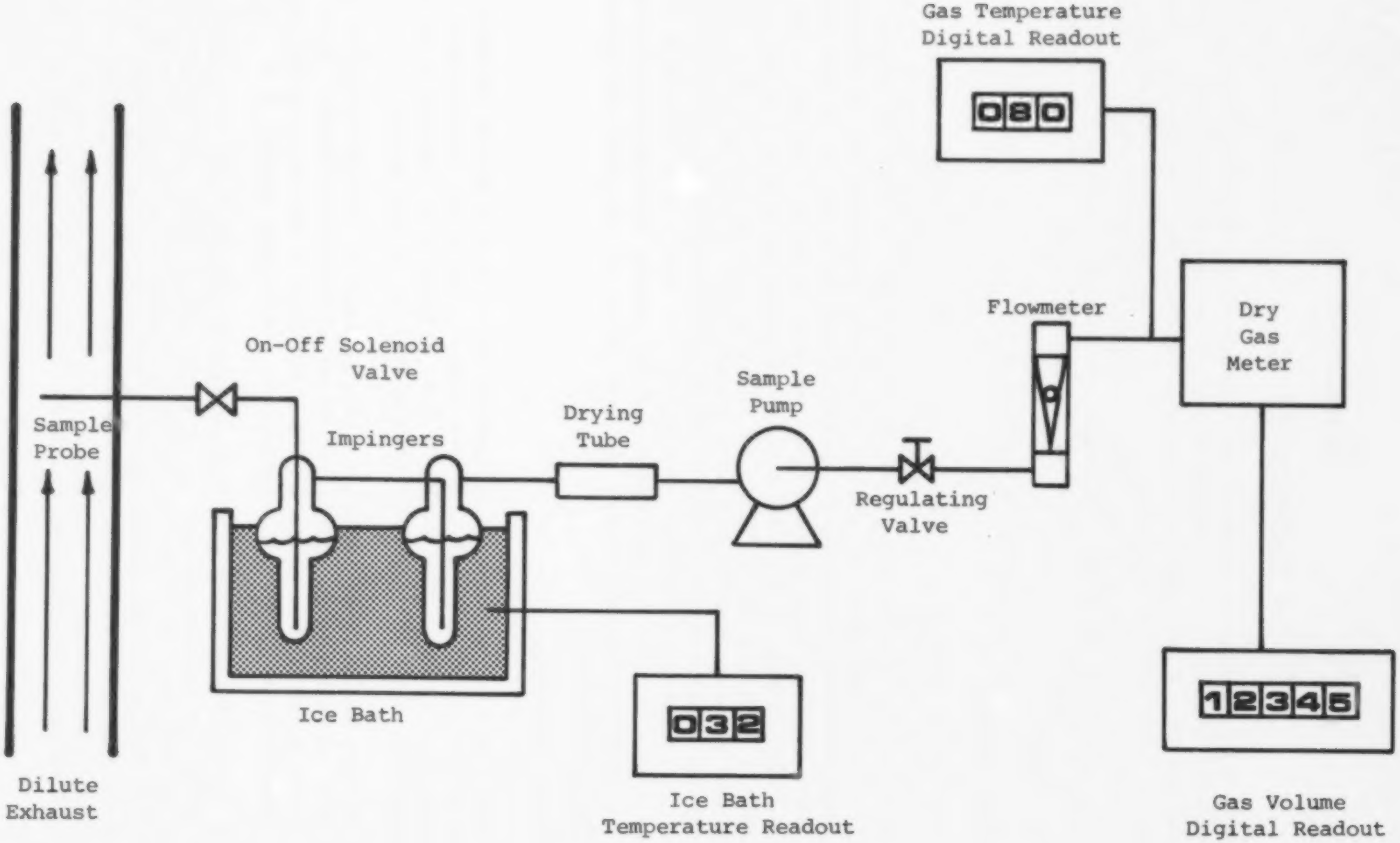
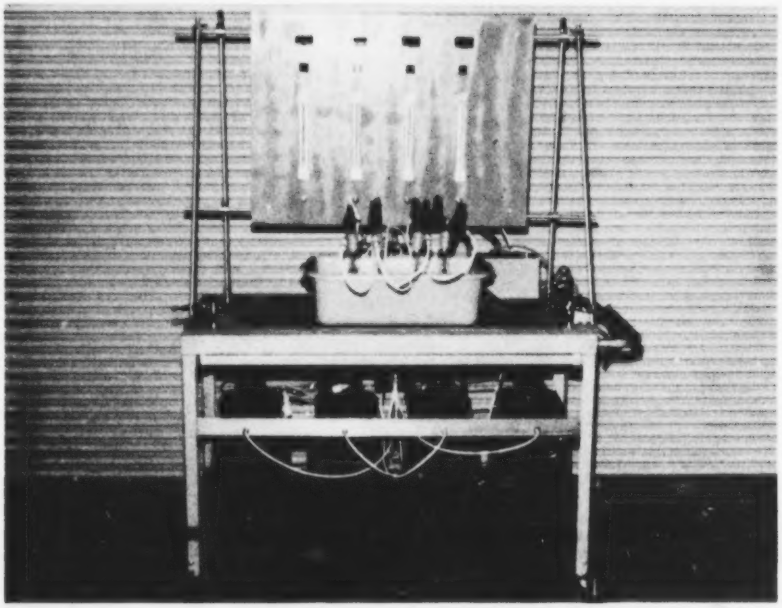
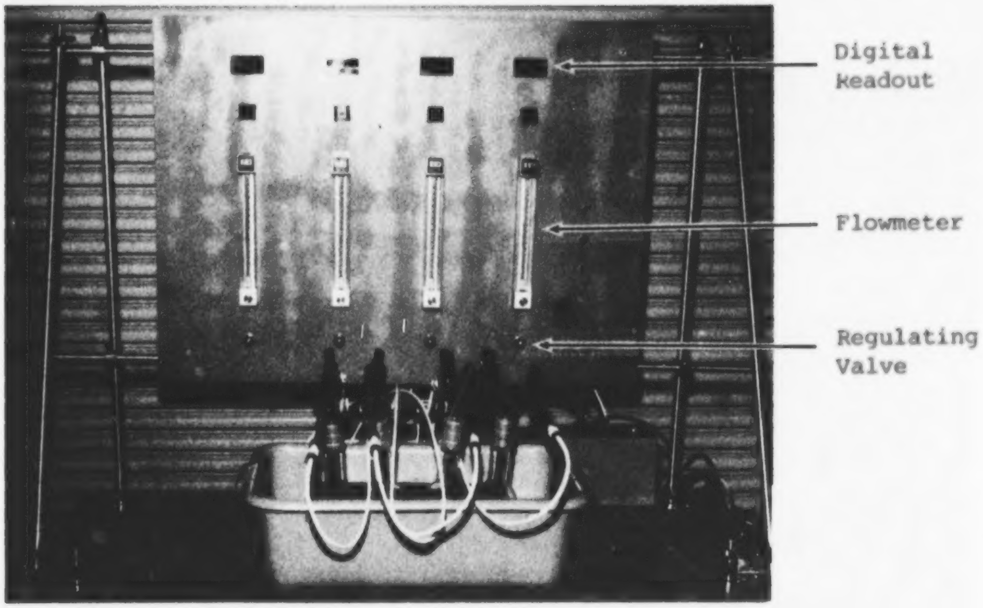

Gas Temperature
Digital Readout
080
Flowmeter
Dry
Gas
Meter
On-Off Solenoid
Valve
Sample
Pump
Drying
Tube
Sample
Probe
Impingers
Regulating
Valve
Ice Bath
032
12345
Dilute
Exhaust
Ice Bath
Temperature Readout
Gas Volume
Digital Readout

Figure 1. Methanol sample collection flow schematic.

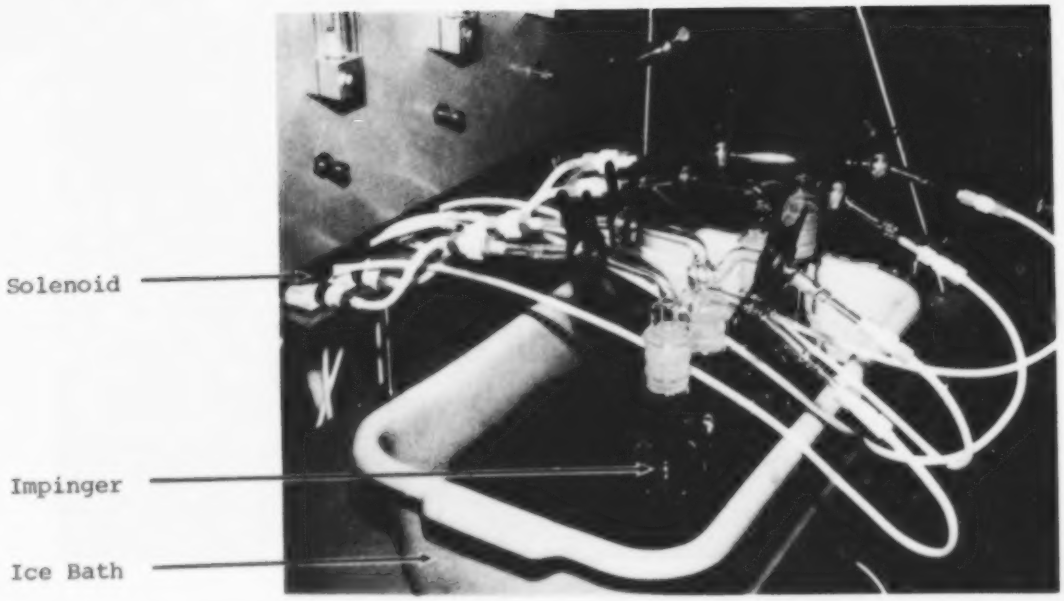


Front View

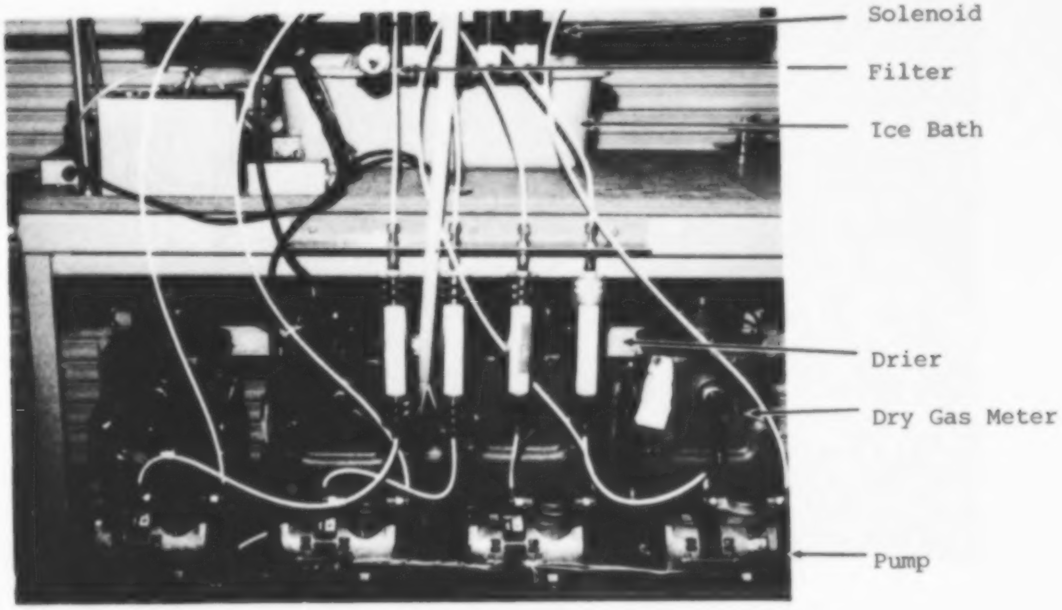

Digital Readout
Flowmeter
Regulating Valve

Close-up of Upper Front

Figure 2. Methanol sampling system.


Solenoid
Impinger
Ice Bath

Close-up of Impingers (Side View)


Solenoid
Filter
Ice Bath
Drier
Dry Gas Meter
Pump

Rear View

Figure 2 (Cont'd). Methanol sampling system.

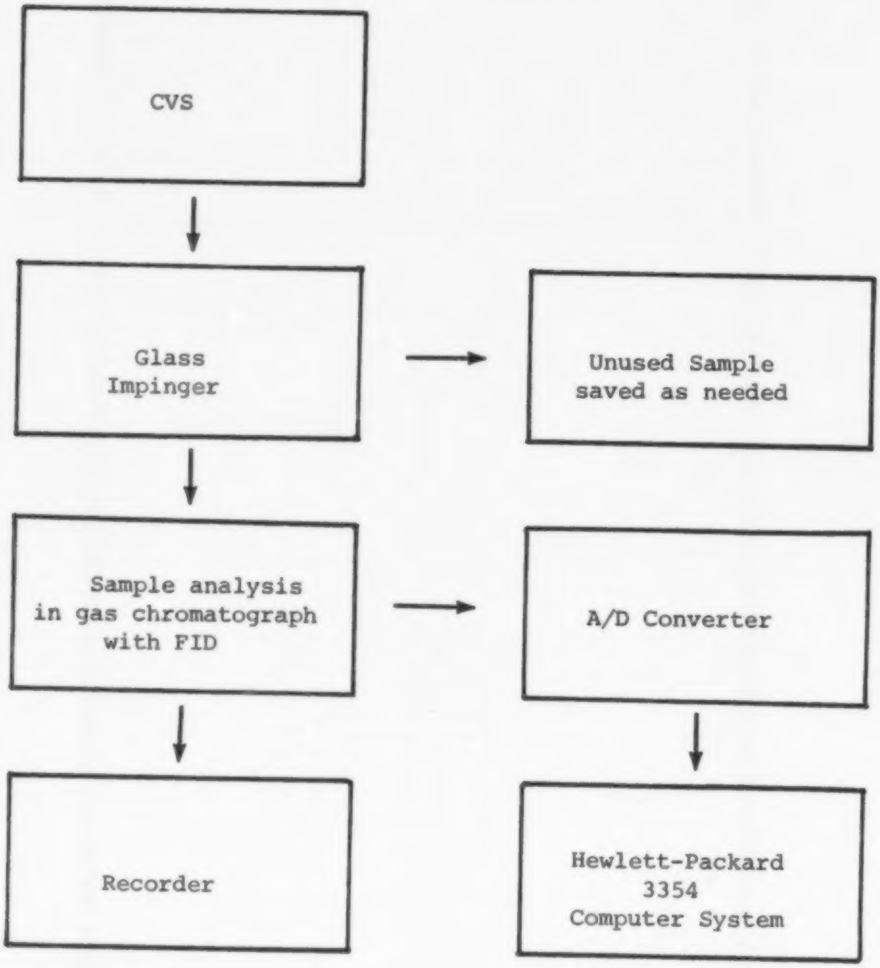
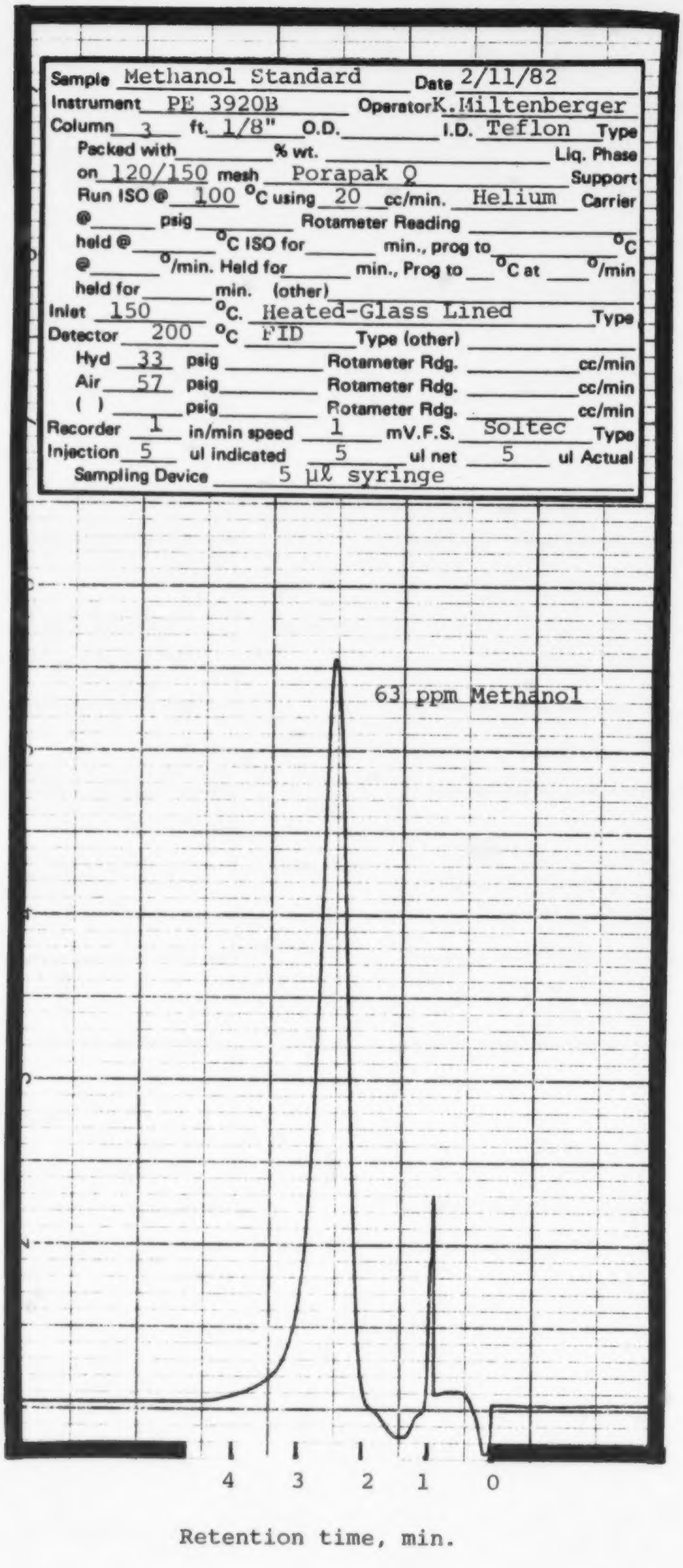

CVS
Glass Impinger
Unused Sample saved as needed
Sample analysis in gas chromatograph with FID
A/D Converter
Recorder
Hewlett-Packard 3354 Computer System

Figure 3. Methanol analysis flow schematic.

</br>

Sample Methanol Standard Date 2/11/82
Instrument PE 3920B Operator K.Miltenberger
Column 3 ft. 1/8" O.D. I.D. Teflon Type
Packed with % wt. Liq. Phase
on 120/150 mesh Porapak Q Support
Run ISO @ 100 °C using 20 cc/min. Helium Carrier
@ psig Rotameter Reading
held @ °C ISO for min., prog to °C
@ °/min. Held for min., Prog to °C at °/min
held for min. (other)
Inlet 150 °C. Heated-Glass Lined Type
Detector 200 °C FID Type (other)
Hyd 33 psig Rotameter Rdg. cc/min
Air 57 psig Rotameter Rdg. cc/min
( ) psig Rotameter Rdg. cc/min
Recorder 1 in/min speed 1 mV.F.S. Soltec Type
Injection 5 ul indicated 5 ul net 5 ul Actual
Sampling Device 5 μℓ syringe

Figure 4. Chromatogram of methanol standard

quantify the results, the sample peak area is compared to the peak area of a standard solution. Figure 5 shows the analytical system with gas chromatograph, detector, A/D converter, and recorder.

CALCULATIONS

The procedure has been developed to provide the user with the concentration of methanol in exhaust. The results will be expressed in $\mu g/m^3$ of exhaust and ppm. The equations for determining the concentrations in $\mu g/m^3$ and ppm are derived in the following manner.

The first step is to correct the volume of exhaust sampled to a standard temperature, 68°F, and pressure, 29.92"Hg, by use of the equation

$$\frac{P_{exp} \times V_{exp}}{T_{exp}} = \frac{P_{corr} \times V_{corr}}{T_{corr}}$$

V_{exp} = experimental volume of gas sampled in ft^3
V_{corr} = volume of gas sampled in ft^3 corrected to 68°F and 29.92"Hg
P_{exp} = experimental barometric pressure
P_{corr} = 29.92"Hg
T_{exp} = experimental temperature in °F + 460
T_{corr} = 68°F + 460 = 528°R

Solving for V_{corr} gives:

$$V_{corr} = \frac{P_{exp}(\text{"Hg}) \times V_{exp}(ft^3) \times 528°R}{T_{exp}(°R) \times 29.92\text{"Hg}}$$

The next step converts the volume from cubic feet to cubic meters by use of the conversion factor: 1 cubic meter is equal to 35.31 cubic feet.

$$V_{corr(m^3)} = \frac{P_{exp}(\text{"Hg}) \times V_{exp}(ft^3) \times 528°R}{T_{exp} \times 29.92\text{"Hg} \times 35.31\ ft^3/m^3}$$

(Equation 1)

The next step is to find the concentration of methanol in $\mu g/m\ell$. Since the gas chromatograph FID has a linear response in the concentration of concern, then the following equation holds.

$$\frac{C_{sam}\ (\mu g/m\ell)}{A_{sam}} = \frac{C_{std}\ (\mu g/m\ell)}{A_{std}}$$

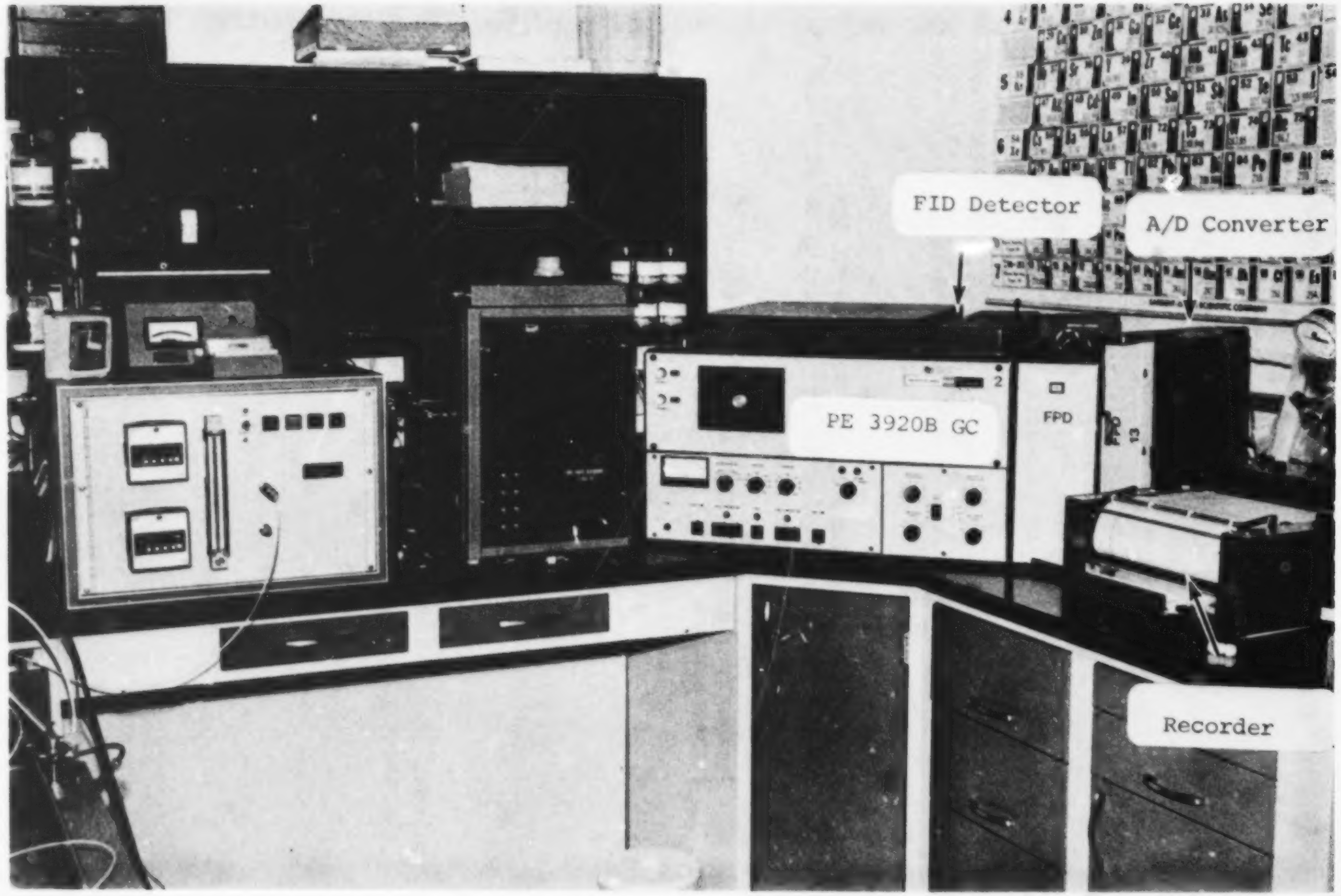

FID Detector
A/D Converter
PE 3920B GC
FPD
Recorder

Figure 5. Methanol analytical system

C_{sam} = concentration of the sample in μg/mℓ
A_{sam} = GC peak area of sample in relative units
C_{std} = concentration of the standard in μg/mℓ
A_{std} = GC peak area of standard in relative units

Solving for C_{sam} gives:

$$C_{sam}(\mu g/m\ell) = \frac{C_{std}\ (\mu g/m\ell) \times A_{sam}}{A_{std}}$$

The $C_{sam}(\mu g/m\ell)$ in solution is corrected for any necessary dilution by multiplying by the dilution factor, D.F.

$$C_{sam}(\mu g/m\ell) = \frac{C_{std}\ (\mu g/m\ell) \times A_{sam} \times \text{D.F.}}{A_{std}}$$

To obtain the total amount in μg of methanol in the aqueous absorbing solution, the absorbing reagent volume is multiplied by the concentration to give:

$$\mu g \text{ sample} = C_{sam}\ (\mu g/m\ell) \times \text{Abs. Vol. } (m\ell)$$

$$= \frac{C_{std}\ (\mu g/m\ell) \times A_{sam} \times \text{D.F.} \times \text{Abs. Vol. } (m\ell)}{A_{std}}$$

(Equation 2)

To obtain μg sample/m^3, Equation 2 is divided by Equation 1 to give:

$$\mu g \text{ samp}/m^3 = \frac{C_{std}\ (\mu g/m\ell) \times A_{sam} \times \text{D.F.} \times \text{Abs. Vol. } (m\ell)}{A_{std} \times P_{exp}\ (\text{"Hg}) \times 528^\circ}$$

$$\times \frac{T_{exp} \times 29.92\text{"Hg} \times 35.31\ (ft^3/m^3)}{V_{exp}\ (ft^3)}$$

(Equation 3)

To find the concentration of methanol in ppm, the density of the methanol is needed. At 29.92"Hg and 32°F, one mole of gas occupies 22.4 liters. This volume is corrected to 68°F from the equation

$$\frac{V}{T} = \frac{V_1}{T_1}$$

$V_1 = 22.4\ell$
$T_1 = 32°F + 460 = 492°R$
V = volume at 68°F
$T = 68°F + 460 = 528°R$

Solving for V gives:

$$V = \frac{V_1 \times T}{T_1} = \frac{22.4 \times 528}{492} = 24.04\ell$$

Since one mole of gas occupies 22.04ℓ at 68°F, the density can be found in g/ℓ by dividing the molecular weight in g/mole by 22.04 ℓ/mole

$$\text{den } (g/\ell) = \frac{\text{mol. wt. g/mole}}{24.04\ \ell/\text{mole}}$$

The density in μg/mℓ can be found by converting g to μg and ℓ to mℓ as follows:

$$\text{den } \mu g/m\ell = \frac{\text{mol. wt. g/mole}}{24.04\ \ell/\text{mole}} \times \frac{1 \times 10^6 \mu g/g}{1 \times 10^3 m\ell/\ell} = \frac{\text{mol. wt.} \times 1000}{24.04}$$

(Equation 4)

To obtain the concentration of methanol in ppm, the concentration in μg/m^3 is divided by the density in μg/mℓ

$$\text{ppm} = \mu g/m^3 \div \mu g/m\ell = \frac{m\ell}{m^3}$$

Using Equations 3 and 4 gives the ppm concentration in the form of the raw data.

$$\text{ppm} = \frac{24.04(\ell) \times C_{std}\ (\mu g/m\ell) \times A_{sam} \times \text{D.F.} \times \text{Abs. Vol. } (m\ell)}{\text{Mol. Wt. } (g/\text{mole}) \times 1000 \times A_{std} \times P_{exp}\ (\text{"Hg})}$$

$$\times \frac{T_{exp}(°R) \times 29.92\text{"Hg} \times 35.31\ ft^3/m^3}{528°R \times V_{exp}\ (ft^3)}$$

(Equation 5)

At this point, the concentration can be expressed in $\mu g/m^3$ (Equation 3) and ppm (Equation 5) at 68°F and 29.92"Hg from the raw data.

Hewlett-Packard Calculations

In order to insure maximum turnaround in a minimum time period, a Hewlett-Packard 67 program was developed to calculate the methanol concentrations in $\mu g/m^3$ and ppm from the raw data. This program is presented in Figure 6.

Sample Calculation

Assume exhaust samples were collected in glass impingers for each portion of a three bag 1975 FTP. Raw data for these tests are presented in Figure 7. Calculations were performed using the HP 67 program and manual calculations.

Manual calculations for driving cycle FTP-1

For Bubbler #1

$$\mu g/m^3 CH_3OH = \frac{C_{std}(\mu g/m\ell) \times A_{sam} \times \text{D.F.} \times \text{Abs. Vol. } (m\ell)}{A_{std} \times P_{exp}\ (\text{"Hg})}$$

$$\times \frac{T_{exp} \times 29.92\text{"Hg} \times 35.31\ ft^3/m^3}{528°R \times V_{exp}\ (ft^3)}$$

$$= \frac{(7.9\ \mu g/m\ell) \times 1000 \times 1 \times 25}{1500 \times 29.80\text{"Hg}}$$

$$\times \frac{(460 + 75) \times 29.92\text{"Hg} \times 35.31\ ft^3/m^3}{528°R \times 3.196\ ft^3}$$

$$= 1480\ \mu g/m^3$$

Figure 6. HP-67

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
0_1	Switch to on; switch to run				
0_2	Feed side 1 of card in from right to left				
0_3	Set decimal place		g	Sci	
1	Input Sample Volume	ft^3	A		
2	Input Barometric Pressure	"Hg	R/S		
3	Input Sample Temperature	°F	R/S		
4	Input Absorbing Reagent Volume	mℓ	R/S		
5	Input Dilution Factor, Bubbler #1		R/S		
6	Input Standard Concentration, Bubbler #1	µg/mℓ	R/S		
7	Input Standard Area, Bubbler #1	counts	R/S		
8	Input Sample Area, Bubbler #1	counts	R/S		
9	Output Sample Conc., Bubbler #1				µg/mℓ
10	Input Dilution Factor, Bubbler #2		R/S		
11	Input Standard Conc., Bubbler #2	µg/mℓ	R/S		
12	Input Standard Area, Bubbler #2	counts	R/S		
13	Input Sample Area, Bubbler #2	counts	R/S		
14	Output Sample Conc, Bubbler #2		R/S		µg/mℓ
15	Output Sample Conc., Bubbler # 1 & #2		R/S		µg/mℓ
16	Output Sample Conc.				ppm
			h	RTN	

Figure 6 (Cont'd). HP-67 Program Form

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	In Sample Vol., ft^3				
	2	02					
	÷	81					
	R/S	84	In Barometric Pressure, "Hg	060			
	X	71					
	STO 1	33 01					
	R/S	84	In Sample Temp, °F				
	4	04					
	6	06					
010	0	00					
	+	61					
	RCL 1	34 01					
	÷	81					
	R/S	84	In Sol. Vol., mℓ	070			
	X	71					
	STO 2	33 02					
	RCL 2	34 02					
	R/S	84	In Dilution Factor				
	X	71					
020	R/S	84	In Std Conc., μg/mℓ				
	X	71					
	R/S	84	In Std. Area				
	÷	81					
	R/S	84	In Sample Area, Bubbler #1	080			
	X	71					
	STO 3	33 03	Out Sample Conc, Bubbler #1, μg/m^3				
	R/S	84					
	RCL 2	34 02	In Dilution Factor				
	X	71					
030	R/S	84	In Std Conc., μg/mℓ				
	X	71					
	R/S	84	Input Std. Area				
	÷	81					
	R/S	84	In Sample Area, Bubbler #2	090			
	X	71					
	R/S	84	Out Sam. Conc, Bubbler #2, μg/m^3				
	RCL 3	34 03					
	+	61					
	R/S	84					
040	1	01	Out Conc., μg/m^3				
	3	03					
	3	03					
	3	03					
	÷	81		100			
	R/S	84	Output ppm Methanol				
	h RTN	35 22					
050							
				110			

REGISTERS

0	1	2	3	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Figure 6 (Cont'd). HP-67 Program Form

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	In Sample Vol., ft^3				
	2	02					
	÷	81					
	R/S	84	In Barometric Pressure, "Hg	060			
	X	71					
	STO 1	33 01					
	R/S	84	In Sample Temp., °F				
	4	04					
	6	06					
010	0	00					
	+	61					
	RCL 1	34 01					
	÷	81					
	R/S	84	In Sol. Vol., mℓ	070			
	X	71					
	STO 2	33 02					
	RCL 2	34 02					
	R/S	84	In Dilution Factor				
	X	71					
020	R/S	84	In Std Conc., µg/mℓ				
	X	71					
	R/S	84	In Std. Area				
	÷	81					
	R/S	84	In Sample Area, Bubbler #1	080			
	X	71					
	STO 3	33 03					
	R/S	84	Out Sample Conc. Bubbler #1, µg/m^3				
	RCL 2	34 02	In Dilution Factor				
	X	71					
030	R/S	84	In Std. Conc., µg/mℓ				
	X	71					
	R/S	84	Input Std. Area				
	÷	81					
	R/S	84	In Sample Area, Bubbler #2	090			
	X	71					
	R/S	84	Out Sample conc., Bubbler #2, µg/m^3				
	RCL 3	34 03					
	+	61					
	R/S	84					
040	1	01	Out Conc., µg/m^3				
	3	03					
	3	03					
	3	03					
	÷	81		100			
	R/S	84	Output ppm Methanol				
	h RTN	35 22					
050							
				110			

REGISTERS

0	1	2	3	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

METHANOL

SWRI PROJECT NO.__________ TEST NO.__________ TEST DATE:__________ VEHICLE:__________

FUEL__________ CVS NO.__________ TUNNEL SIZE:__________ DRIVER:__________ MILES:__________

SAMPLE COLLECTION BY: __________ CHEMICAL ANALYSIS BY:__________ CALCULATIONS BY:__________

GENERAL COMMENTS__________

Test No.	1	2	3	4	5	6
Driving Cycle	FTP-1	FTP-1	FTP-3	SET-7	HFET	NYCC
Volume, Ft^3	3.196	1.625	2.010	3.730	8.241	1.070
B.P., "Hg	29.80	30.02	29.02	29.25	29.95	29.50
Temp. °F	75	80	96	85	83	89
Absor. Rea. Vol., mℓ	25	25	50	50	75	75
Dilution Factor, Bubbler #1	1	5	10	2	1	1
Std. Conc μgCH_3OH/mℓ Bub. #1	7.9	79	790	7.9	7.9	0.79
Std. Area - Bubbler #1	1500	5000	10000	1000	5000	1000
Sample Area - Bubbler #1	1000	1000	1000	3000	15000	3000
Sample Conc μgCH_3OH/m^3, Bub#1	1480	43700	753000	23700	7820	6180
Dilution Factor, Bubbler #2	1	2	5	1	1	1
Std. Conc μgCH_3OH/mℓBub. #2	0.79	7.9	7.9	0.79	0.79	0.79
Std. Area - Bubbler #2	2000	1500	5000	1000	6000	5000
Sample Area - Bubbler #2	500	300	6000	100	1000	15000
Sample Conc μgCH_3OH/m^3,Bub#2	55.5	1750	45200	39.5	43.5	6180
Total Conc. μgCH_3OH/m^3	1530	45500	798000	23700	7860	12400
PPM Methanol	1.15	34.1	599	17.8	5.90	9.28

Figure 7. Methanol sample collection sheet

The concentration in Bubbler #2 is calculated in the same manner using the appropriate dilution factor, standard concentration, standard area, and sample area:

For Bubbler #2:

$$\mu g/m^3 = \frac{0.79\ \mu g/m\ell \times 500 \times 1 \times 25}{2000 \times 29.80}$$

$$\times \frac{(460 + 75) \times 29.92''Hg \times 35.31\ ft^3/m^3}{528°R \times 3.196\ ft^3}$$

$$= 55.5\ \mu g/m\ell^3$$

The concentrations from the two bubblers can be added for a total concentration:

$$\begin{aligned}\text{Total } \mu g \text{ methanol}/m^3 &= \text{conc.(Bubbler \#1)} + \text{conc.(Bubbler \#2)}\\ &= 1480\ \mu g/m^3 + 55.5\ \mu g/m^3\\ &= 1535\ \mu g/m^3\end{aligned}$$

$$\text{PPM } CH_3OH = \mu g/m^3 \div \text{density } \mu g/m\ell$$

$$\text{density } \mu g/m\ell = \frac{\text{Mol. Wt. } (CH_3OH) \times 1000}{24.04\ell}$$

Mol. Wt. CH_3OH = 32.04 g/mole

$$\text{density} = \frac{32.04 \times 1000}{24.04\ell} = 1333\ \mu g/m\ell$$

$$\text{ppm} = 1535 \div 1333\ \mu g/m\ell = 1.15\ m\ell/m^3 = 1.15\ \text{ppm}$$

Note: The values used in these calculations are picked from a range of temperatures, standards, dilution factors, etc., to validate the calculations and may not be representative of expected raw data. These calculations are presented to confirm that the manual and HP-67 calculations give the same results. This was confirmed on six sets of calculations.

LIST OF EQUIPMENT AND REAGENTS

The equipment and reagents for the analysis of the methanol is divided into two groups. The first involves the sample acquisition and the second the instrumental analysis of the sample once it has been obtained. Manufacturer, stock number and any pertinent descriptive information are listed. The preparation of standards is also discussed.

Sampling

1. Glass impingers, Ace Glass Products, Catalog #7530-11, plain tapered tip stoppers with 18/7 arm joints and 29/42 bottle joints.
2. Flowmeter, Brooks Instrument Division, Model 1555, tube size R-2-15-C, graduated 0-15, sapphire float, 0-5 ℓ/min range.
3. Sample pump, Thomas Model 106 CA18, capable of free flow capacity of 4 ℓ/min.
4. Dry gas meter, American Singer Corporation, Type AL-120, 60 CFH capacity.
5. Regulating valve, Nupro 4MG, stainless steel.
6. Teflon tubing, United States Plastic Corporation, 1/4" OD x 1/8" ID and 5/16" OD x 1/8" ID.
7. Teflon solenoid valve, the Fluorocarbon Company, Model DV2-144NCA1.
8. Drying tube, Analabs Inc., Catalog #HGC-146, 6" long, 1/4" brass fittings.
9. Miscellaneous Teflon nuts, ferrules, unions, tees, clamps, connectors, etc.
10. Digital readout for dry gas meter.
11. Miscellaneous electrical switches, lights, wirings, etc.
12. Six channel digital thermometer, Analog Devices, Model #2036/J/1.
13. Iron/Constantan type J single thermocouple with 1/4" OD stainless steel metal sheath, Thermo Sensors Corporation.
14. 30 mℓ polypropylene sample storage bottles, Nalgene Labware, Catalog #2006-0001.
15. Deionized or distilled water.
16. Class A, 10 mℓ volumetric pipet.
17. Class A, 1000 mℓ volumetric flask.

Instrumental Analysis

1. 5 µl syringe, Hamilton Co., Reno, Nevada.
2. Perkin-Elmer Model 3920 B gas chromatograph equipped with flame ionization detector.
3. Soltec Model B-281 1 mv recorder.
4. Hewlett-Packard Model 3354 gas chromatograph computer system with remote teletype printout.

Preparation of Primary Standards

The primary standard for the methanol analysis is prepared by diluting a known volume of methanol with deionized (or distilled) water. Standards less than ∿500 ppm are prepared by diluting higher concentration standards with deionized water.

APPENDIX B

INDIVIDUAL AND AVERAGE TEST RESULTS SUMMARY TABLES

Table B-	Car No.	Car	Fuel	Catalyst
1	81	Escort	Indolene	Noble Metal
2	82	Escort	Anafuel	Noble Metal
3	83	Escort	Methanol	Noble Metal
4	84	Rabbit	Methanol	Noble Metal
5	85	Rabbit	Indolene	Noble Metal
6	86	Rabbit	Methanol	Promoted Base Metal
7	87	Escort	Methanol	Promoted Base Metal
8	88	Escort	Methanol	None
9	89	Rabbit	Methanol	Promoted Base Metal
10	90	Escort	Methanol	Noble Metal

TABLE B-1. CAR 81 EMISSIONS SUMMARY
1981 Ford Escort Wagon - Indolene Fuel

	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
Test Number, PVS	811	812	813	Average	811	812	813	Average
Barometer, mm Hg	740.4	745.0	745.7	743.7	740.2	745.0	746.0	743.7
Humidity, g/kg	12.4	11.1	9.9	11.1	14.0	10.4	10.9	11.8
Carbon Dioxide, g/km	219.0	223.3	216.1	219.5	146.5	143.3	142.1	144.0
Fuel Cons., ℓ/100 km	9.56	9.78	9.42	9.59	6.36	6.18	6.14	6.23
Regulated Emissions								
Hydrocarbons, (THC), g/km	0.23	0.24	0.22	0.23	0.10	0.11	0.09	0.10
Carbon Monoxide, g/km	2.68	3.15	2.54	2.79	1.41	0.80	0.94	1.05
Oxides of Nitrogen, g/km	0.35	0.36	0.32	0.34	0.29	0.35	0.28	0.31
Other Emissions								
Total Particulates	7.30	5.36	4.56	5.74	1.93	1.27	0.95	1.38
Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethanol	0.	0.	0.	0.	0.	0.	0.	0.
Aldehydes & Ketones	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0
Individual Hydrocarbons	90.	99.	99.	96.	48.	46.	47.	47.
Nitrosamines				0.000				
Aldehydes & Ketones								
Formaldehyde	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0
Acetaldehyde	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acetone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methyl Ethyl Ketone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hexanaldehyde	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Individual Hydrocarbons								
Methane	57.2	58.0	63.9	59.7	28.0	24.8	28.9	27.2
Ethylene	4.7	6.1	5.4	5.4	3.4	3.5	2.7	3.2
Ethane	11.0	11.6	11.3	11.3	7.2	7.9	7.8	7.6
Acetylene	0.8	1.3	0.6	0.9	0.0	0.0	0.0	0.0
Propane	0.0	0.4	1.2	0.5	0.0	0.0	0.6	0.2
Propylene	2.8	4.5	3.9	3.8	2.5	3.7	2.6	2.9
Benzene	3.6	4.3	3.8	3.9	2.3	2.1	1.6	2.0
Toluene	9.9	13.3	8.8	10.7	4.1	3.6	2.9	3.5

TABLE B-2. CAR 82 EMISSIONS SUMMARY
1981 Ford Escort - Anafuel

	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
Test Number, PVS	821	822	823	Average	821	822	823	Average
Barometer, mm Hg	743.7	742.7	741.9	742.8	743.7	743.0	741.7	742.8
Humidity, g/kg	11.4	15.0	10.2	12.2	10.4	11.9	10.0	10.8
Carbon Dioxide, g/km	218.5	218.9	214.9	217.4	148.2	142.9	141.3	144.1
Fuel Cons., ℓ/100 km	9.61	9.63	9.47	9.57	6.48	6.21	6.18	6.29
Regulated Emissions								
Hydrocarbons, (THC), g/km	0.18	0.18	0.21	0.19	0.06	0.04	0.05	0.05
Carbon Monoxide, g/km	1.87	2.05	2.14	2.02	0.80	0.31	0.69	0.60
Oxides of Nitrogen, g/km	0.41	0.46	0.39	0.42	0.38	0.55	0.32	0.42
Other Emissions								
Total Particulates	3.54	3.31	3.69	3.51	1.14	1.20	--	1.17
Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethanol	0.	0.	0.	0.	0.	0.	0.	0.
Aldehydes & Ketones	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Individual Hydrocarbons	74.	73.	76.	74.	25.	19.	21.	22.
Nitrosamines				0.000				
Aldehydes & Ketones								
Formaldehyde	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Acetaldehyde	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acetone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methyl Ethyl Ketone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hexanaldehyde	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Individual Hydrocarbons								
Methane	43.1	42.1	42.6	42.6	16.5	12.2	14.2	14.3
Ethylene	5.3	5.7	5.7	5.6	2.0	1.7	1.6	1.8
Ethane	4.4	4.7	3.4	4.2	2.2	2.4	1.8	2.1
Acetylene	1.1	0.9	1.1	1.0	0.0	0.0	0.0	0.0
Propane	0.4	0.1	0.2	0.2	0.0	0.1	0.0	0.0
Propylene	2.2	1.9	2.0	2.0	0.3	0.0	0.0	0.1
Benzene	4.5	4.2	5.2	4.6	1.3	0.8	1.4	1.1
Toluene	12.6	13.4	15.8	13.9	2.5	1.9	2.3	2.2

TABLE B-3. CAR 83 EMISSIONS SUMMARY
1981 Ford Escort - Methanol Fuel

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	831	832	833	Average	831	832	833	Average
Barometer,	mm Hg	741.2	737.9	739.9	739.7	741.4	737.6	741.4	740.1
Humidity,	g/kg	10.7	12.8	10.5	11.3	10.9	11.8	8.4	10.4
Carbon Dioxide,	g/km	196.6	203.6	192.1	197.4	139.2	148.2	137.4	141.6
Fuel Cons.,	ℓ/100 km	18.76	19.26	18.17	18.73	12.87	13.69	12.68	13.08
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.27	0.25	0.27	0.26	0.06	0.05	0.05	0.05
Carbon Monoxide,	g/km	4.51	3.50	3.24	3.75	0.45	0.26	0.28	0.33
Oxides of Nitrogen,	g/km	0.23	0.26	0.25	0.25	0.18	0.23	0.18	0.20
Particulates									
Total Particulates		4.13	3.97	3.52	3.87	7.13	7.50	4.13	6.25
Compound Group Totals									
Aldehydes & Ketones		28.0	15.0	19.5	20.8	11.4	15.7	18.2	15.1
Individual Hydrocarbons		36.9	30.6	25.6	31.0	3.4	4.0	3.0	3.5
Organic Amines		0.00	0.02		0.01				
Nitrosamines					0.000				
Other Emissions									
Methanol		286.5	193.3	277.6	252.5	47.9	41.1	35.7	38.2
Ethanol		0.	0.	0.	0.	0.	0.	0.	0.
Ammonia		5.62	6.79		6.21				
Cyanide & Cyanogens		0.00	0.00		0.00				

TABLE B-3(Cont'd). CAR 83 EMISSIONS SUMMARY
1981 Ford Escort - Methanol Fuel

	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
Test Number, PVS	831	832	833	Average	831	832	833	Average
Aldehydes & Ketones								
Formaldehyde	26.97	15.00	19.53	20.50	10.72	15.68	18.17	14.86
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetone	1.04	0.00	0.00	0.35	0.70	0.00	0.00	0.23
Methyl Ethyl Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Individual Hydrocarbons								
Methane	35.78	29.05	25.12	29.98	3.02	3.11	2.87	3.00
Ethylene	0.40	0.04	0.00	0.15	0.25	0.00	0.00	0.08
Ethane	0.33	0.16	0.43	0.31	0.08	0.00	0.11	0.07
Acetylene	0.00	0.12	0.00	0.04	0.00	0.00	0.00	0.00
Propane	0.36	0.70	0.00	0.35	0.00	0.86	0.00	0.29
Propylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.08	0.00	0.03	0.00	0.00	0.00	0.00
Toluene	0.00	0.44	0.00	0.15	0.00	0.00	0.00	0.00
Organic Amines								
Monomethylamine	0.00	0.02		0.01				
Monoethylamine + dimethylamine	0.00	0.00		0.00				
Trimethylamine	0.00	0.00		0.00				
Diethylamine	0.00	0.00		0.00				
Triethylamine	0.00	0.00		0.00				

TABLE B-4. CAR 84 EMISSIONS SUMMARY - 1981 VW Rabbit - Methanol Fuel

	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
Test Number, PVS	841	842	843	Average	841	842	843	Average
Barometer, mm Hg	750.3	751.8	745.7	749.3	750.8	752.1	745.7	749.5
Humidity, g/kg	5.9	6.4	9.0	7.1	6.5	5.2	9.2	7.0
Carbon Dioxide, g/km	186.2	179.8	185.2	183.7	150.6	149.7	147.1	149.1
Fuel Cons., ℓ/100 km	17.24	16.64	17.13	17.00	13.87	13.74	13.54	13.72
Regulated Emissions								
Hydrocarbons, (THC), g/km	0.27	0.27	0.18	0.24	0.00	0.01	0.01	0.01
Carbon Monoxide, g/km	0.59	0.54	0.53	0.55	0.17	0.14	0.11	0.14
Oxides of Nitrogen, g/km	0.41	0.40	0.45	0.42	0.12	0.13	0.14	0.13
Other Emissions								
Total Particulates	2.46	3.19	3.11	2.92	7.76	6.48	--	7.12
Methanol	319.8	278.6	219.1	272.5	0.0	0.0	2.2	0.7
Ethanol	0.	0.	0.	0.	0.	0.	0.	0.
Aldehydes & Ketones	6.6	--	6.2	6.4	0.0	0.0	0.1	0.0
Individual Hydrocarbons	3.6	2.6	3.4	3.2	1.2	0.0	0.7	0.6
Nitrosamines				000.0				
Aldehydes & Ketones								
Formaldehyde	6.59	--	6.15	6.37	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methyl Ethyl Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Individual Hydrocarbons								
Methane	3.49	2.43	3.15	3.02	1.20	0.00	0.73	0.64
Ethylene	0.02	0.03	0.00	0.02	0.00	0.00	0.00	0.00
Ethane	0.09	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Acetylene	0.00	0.18	0.20	0.13	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE B-5. CAR 85 EMISSIONS SUMMARY - 1981 VW Rabbit - Indolene Fuel

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	851	852	853	Average	851	852	853	Average
Barometer,	mm Hg	751.6	739.6	743.5	744.9	751.6	739.1	743.7	744.8
Humidity,	g/kg	5.7	12.0	9.0	8.9	5.8	11.8	9.5	9.0
Carbon Dioxide,	g/km	226.7	236.9	228.6	230.7	177.5	184.2	177.3	179.7
Fuel Cons.,	ℓ/100 km	9.73	10.17	9.81	9.90	7.64	7.93	7.63	7.73
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.07	0.07	0.06	0.07	0.07	0.07	0.06	0.07
Carbon Monoxide,	g/km	0.59	0.72	0.71	0.67	0.78	0.80	0.75	0.78
Oxides of Nitrogen,	g/km	0.11	0.09	0.11	0.10	0.04	0.05	0.03	0.04
Other Emissions									
Total Particulates		9.73	7.39	4.78	7.30	23.56	25.03	11.29	19.96
Methanol		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ethanol		0.	0.	0.	0.	0.	0.	0.	0.
Aldehydes & Ketones		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Individual Hydrocarbons		25.8	28.5	21.2	25.2	38.0	39.2	33.1	36.8
Nitrosamines					0.000				
Aldehydes & Ketones									
Formaldehyde		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetaldehyde		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetone		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methyl Ethyl Ketone		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanaldehyde		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Individual Hydrocarbons									
Methane		8.36	9.34	8.40	8.70	17.25	17.81	16.14	17.07
Ethylene		2.72	3.40	2.87	3.00	2.57	2.84	2.33	2.58
Ethane		1.55	1.62	1.61	1.59	4.08	4.06	3.53	3.89
Acetylene		0.97	1.20	1.08	1.08	0.00	0.00	0.00	0.00
Propane		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Propylene		2.43	2.80	--	2.62	3.36	3.05	--	3.21
Benzene		3.88	4.15	1.88	3.30	6.28	6.51	6.59	6.46
Toluene		5.86	5.98	5.36	5.73	4.45	4.91	4.47	4.61

TABLE B-6. CAR 86 EMISSIONS SUMMARY - 1981 VW Rabbit
With Base-Metal Catalyst

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	861	862	863	Average	861	862	863	Average
Barometer,	mm Hg	754.1	735.1	729.7	739.6	754.9	735.1	730.5	740.2
Humidity,	g/kg	3.3	11.1	8.3	7.6	3.0	11.1	11.2	8.5
Carbon Dioxide,	g/km	182.0	179.7	187.5	183.1	143.7	144.8	152.1	146.9
Fuel Cons.,	ℓ/100 km	17.09	16.92	17.66	17.22	13.51	13.63	14.29	13.81
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.52	0.53	0.56	0.54	0.16	0.17	0.16	0.16
Carbon Monoxide,	g/km	2.02	2.27	2.43	2.24	1.96	2.04	1.99	2.00
Oxides of Nitrogen,	g/km	1.07	1.06	1.14	1.09	1.06	1.05	1.17	1.09
Other Emissions									
Total Particulates		--	--	--	--	--	--	--	--
Methanol		428.1	598.0	692.1	572.7	--	194.0	170.9	182.5
Ethanol		0.	0.	0.	0.	0.	0.	0.	0.
Aldehydes & Ketones		28.8	33.0	28.6	30.1	6.2	19.5	15.4	13.7
Individual Hydrocarbons		10.2	9.0	10.9	10.0	5.8	5.6	4.6	5.3
Nitrosamines					0.000				
Aldehydes & Ketones									
Formaldehyde		28.81	32.95	28.56	30.11	6.19	19.47	15.40	13.69
Acetaldehyde		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetone		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methyl Ethyl Ketone		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanaldehyde		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Individual Hydrocarbons									
Methane		7.95	7.12	7.46	7.51	4.46	4.32	3.92	4.23
Ethylene		1.49	1.87	1.06	1.47	1.18	1.31	0.68	1.06
Ethane		0.21	0.00	0.21	0.14	0.16	0.00	0.04	0.07
Acetylene		0.00	0.00	2.12	0.71	0.00	0.00	0.00	0.00
Propane		0.55	0.00	0.08	0.21	0.00	0.00	0.00	0.00
Propylene		--	--	--	--	--	--	--	--
Benzene		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE B-7. CAR 87 EMISSIONS SUMMARY - 1981 Ford Escort
With Base Metal Catalyst

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	871	872	873	Average	874	872	873	Average
Barometer,	mm Hg	744.2	754.9	740.7	746.6	741.2	754.6	740.9	745.6
Humidity,	g/kg	5.0	4.9	10.7	6.9	10.5	3.7	10.0	8.1
Carbon Dioxide,	g/km	204.2	199.9	192.9	199.0	136.0	136.0	135.7	135.9
Fuel Cons.,	ℓ/100 km	18.94	18.54	17.90	18.46	12.51	12.52	12.48	12.50
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.19	0.21	0.16	0.19	0.01	0.03	0.01	0.02
Carbon Monoxide,	g/km	0.97	0.91	0.95	0.94	0.05	0.09	0.06	0.07
Oxides of Nitrogen,	g/km	0.25	0.19	0.21	0.22	0.14	0.14	0.14	0.14
Particulates									
Total Particulates		2.48	2.05	2.53	2.35	2.79	1.91	2.57	2.42
Compound Group Totals									
Aldehydes & Ketones		2.4	1.8	2.0	2.1	0.0	0.0	0.0	0.0
Individual Hydrocarbons		26.1	23.6	22.5	24.1	3.4	4.2	3.7	3.8
Organic Amines		0.00	0.00		0.00				
Nitrosamines					0.000				
Other Emissions									
Methanol		92.7	57.5	132.4	94.2	0.6	0.0	0.0	0.2
Ethanol		0.	0.	0.	0.	0.	0.	0.	0.
Ammonia		3.59		3.09	3.34				
Cyanide & Cyanogens			0.09	0.13	0.11				

TABLE B-7(Cont'd). CAR 87 EMISSIONS SUMMARY - 1981 Ford Escort
With Base-Metal Catalyst

Test Number, PVS	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
	871	872	873	Average	874	872	873	Average
Aldehydes & Ketones								
Formaldehyde	2.17	1.76	2.00	1.98	0.00	0.00	0.00	0.00
Acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acetone	0.23	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Methyl Ethyl Ketone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanaldehyde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Individual Hydrocarbons								
Methane	23.60	21.53	21.66	22.26	3.36	3.88	3.70	3.65
Ethylene	0.16	0.13	0.12	0.14	0.00	0.00	0.00	0.00
Ethane	1.80	1.35	0.68	1.28	0.03	0.32	0.03	0.13
Acetylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Propane	0.54	0.55	0.00	0.36	0.00	0.00	0.00	0.00
Propylene	--	0.00	0.00	0.00	--	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Organic Amines								
Monomethylamine	0.00	0.00		0.00				
Monoethylamine + dimethylamine	0.00	0.00		0.00				
Trimethylamine	0.00	0.00		0.00				
Diethylamine	0.00	0.00		0.00				
Triethylamine	0.00	0.00		0.00				

TABLE B-8. CAR 88 EMISSIONS SUMMARY-1981 FORD ESCORT WITHOUT CATALYTIC AFTERTREATMENT

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	881	882		Average	881	882		Average
Barometer,	mm Hg	752.1	752.9		752.5	752.3	752.1		752.2
Humidity,	g/kg	3.8	1.8		2.8	3.6	2.1		2.9
Carbon Dioxide,	g/km	161.9	156.2		159.1	127.4	123.7		125.6
Fuel Cons.,	ℓ/100 km	18.91	19.27		19.09	12.79	12.47		12.63
Regulated Emissions									
Hydrocarbons, (THC),	g/km	5.52	7.25		6.39	2.51	2.45		2.48
Carbon Monoxide,	g/km	23.02	27.65		25.34	5.28	5.46		5.37
Oxides of Nitrogen,	g/km	0.41	0.35		0.38	0.19	0.17		0.18
Particulates									
Total Particulates		8.42	5.27		6.85	4.19	2.40		3.30
Compound Group Totals									
Aldehydes & Ketones		222.3	220.4		221.4	256.3	216.4		236.4
Individual Hydrocarbons		40.4	55.7		48.1	5.8	6.5		6.2
Organic Amines		0.1	0.6		0.4				
Nitrosamines					0.000				
Other Emissions									
Methanol		6553.2	7699.1		7126.2	3313.7	2889.8		3101.8
Ethanol		0.	0.		0.	0.	0.		0.
Ammonia		0.00	4.26		2.13				
Cyanide & Cyanogens		0.03	0.06		0.05				

Table B-8 (Cont'd). CAR 88 EMISSIONS SUMMARY-1981 FORD ESCORT
WITHOUT CATALYTIC AFTERTREATMENT

	EMISSION RATE, MG/KM (Except as Noted)							
	FTP				HFET			
Test Number, PVS	881	882		Average	881	882		Average
Aldehydes & Ketones								
Formaldehyde	222.30	219.85		221.08	255.84	215.36		235.60
Acetaldehyde	0.00	0.00		0.00	0.00	0.00		0.00
Acetone	0.00	0.00		0.00	0.50	0.00		0.25
Methyl Ethyl Ketone	0.00	0.52		0.26	0.00	1.06		0.53
Hexanaldehyde	0.00	0.00		0.00	0.00	0.00		0.00
Individual Hydrocarbons								
Methane	36.50	46.37		41.44	5.25	5.51		5.38
Ethylene	2.89	3.51		3.20	0.58	0.30		0.44
Ethane	0.26	0.48		0.37	0.00	0.07		0.04
Acetylene	0.71	2.86		1.79	0.00	0.00		0.00
Propane	0.00	2.43		1.22	0.00	0.61		0.31
Propylene	--	--		--	--	--		--
Benzene	0.00	0.00		0.00	0.00	0.00		0.00
Toluene	0.00	0.00		0.00	0.00	0.00		0.00
Organic Amines								
Monomethylamine	0.08	0.35		0.22				
Monoethylamine + dimethylamine	0.00	0.00		0.00				
Trimethylamine	0.00	0.20		0.10				
Diethylamine	0.00	0.00		0.00				
Triethylamine	0.00	0.00		0.00				

TABLE B-9. CAR 89 EMISSIONS SUMMARY-1981 VW RABBIT - REEVALUATION OF BASE-METAL CATALYST

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	891	892		Average	891	892		Average
Barometer,	mm Hg	745.7	739.9		742.8	746.3	739.4		742.9
Humidity,	g/kg	11.4	12.4		11.9	10.6	8.5		9.6
Carbon Dioxide,	g/km	179.6	182.7		181.2	148.5	151.6		150.1
Fuel Cons.,	ℓ/100 km	16.79	17.09		16.94	13.76	14.08		13.92
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.29	0.31		0.30	0.04	0.04		0.04
Carbon Monoxide,	g/km	1.70	1.70		1.70	0.69	0.94		0.82
Oxides of Nitrogen,	g/km	0.90	0.98		0.94	0.85	1.00		0.93
Other Emissions									
Total Particulates		3.69	3.43		3.56	4.04	3.58		3.81
Methanol		322.8	349.7		336.3	15.2	31.3		23.3
Aldehydes & Ketones		22.7	17.9		20.3	0.0	2.4		1.2
Individual Hydrocarbons		10.2	10.1		10.2	6.0	4.8		5.4
Nitrosamines					0.000				
Aldehydes & Ketones									
Formaldehyde		22.71	17.89		20.30	0.00	0.00		0.00
Acetaldehyde		0.00	0.00		0.00	0.00	0.00		0.00
Acetone		0.00	0.00		0.00	0.00	0.00		0.00
Methyl Ethyl Ketone		0.00	0.00		0.00	0.00	2.35		1.18
Hexanaldehyde		0.00	0.00		0.00	0.00	0.00		0.00
Individual Hydrocarbons									
Methane		8.26	6.34		7.30	4.57	3.56		4.07
Ethylene		1.26	0.55		0.91	0.84	0.30		0.57
Ethane		0.69	0.26		0.48	0.54	0.26		0.40
Acetylene		0.00	0.11		0.06	0.00	0.00		0.00
Propane		0.00	1.85		0.93	0.00	0.64		0.32
Propylene		0.00	0.00		0.00	0.00	0.00		0.00
Benzene		0.00	0.95		0.48	0.00	0.00		0.00
Toluene		0.00	0.00		0.00	0.00	0.00		0.00

TABLE B-10. CAR 90 EMISSIONS SUMMARY-1981 FORD ESCORT WITH NOBLE METAL CATALYST AND NEW CARBURETOR

		EMISSION RATE, MG/KM (Except as Noted)							
		FTP				HFET			
Test Number,	PVS	901	902		Average	901	902		Average
Barometer,	mm Hg	746.5	740.9		743.7	745.5	740.4		743.0
Humidity,	g/kg	4.3	7.4		5.9	4.7	5.7		5.2
Carbon Dioxide,	g/km	192.3	197.3		194.8	132.9	138.2		135.6
Fuel Cons.,	ℓ/100 km	17.92	18.39		18.16	12.26	12.75		12.51
Regulated Emissions									
Hydrocarbons, (THC),	g/km	0.28	0.30		0.29	0.07	0.06		0.07
Carbon Monoxide,	g/km	1.37	1.46		1.42	0.27	0.25		0.26
Oxides of Nitrogen,	g/km	0.24	0.26		0.25	0.16	0.21		0.19
Other Emissions									
Total Particulates		2.86	--		2.86				
Methanol		240.7	285.0		262.9				
Aldehydes & Ketones		10.9	10.1		10.5				
Aldehydes & Ketones									
Formaldehyde		10.85	10.06		10.46				
Acetaldehyde		0.00	0.00		0.00				
Acetone		0.00	0.00		0.00				
Methyl Ethyl Ketone		0.00	0.00		0.00				
Hexanaldehyde		0.00	0.00		0.00				

APPENDIX C

FTP INDIVIDUAL SAMPLE RESULTS

Table C-	Test No.	Car	Fuel	Catalyst
1-3	811-3	Escort	Indolene	Noble Metal
4-6	821-3	Escort	Anafuel	Noble Metal
7-9	831-3	Escort	Methanol	Noble Metal
10-12	841-3	Rabbit	Methanol	Noble Metal
13-15	851-3	Rabbit	Indolene	Noble Metal
16-18	861-3	Rabbit	Methanol	Promoted Base Metal
19-21	871-3	Escort	Methanol	Promoted Base Metal
22-23	881-2	Escort	Methanol	None
24-25	891-2	Rabbit	Methanol	Promoted Base Metal
26-27	901-2	Escort	Methanol	Noble Metal

Table C-1. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Indolene Fuel

Test 811

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	10.26	5.07
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.25
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	9.68	3.77	5.25	3.44
Ethylene	1.64	0.17	0.54	0.16
Ethane	0.93	1.05	1.15	0.99
Acetylene	0.52	0.00	0.00	0.00
Propane	0.02	0.00	0.00	0.00
Propylene	1.31	0.00	0.40	0.00
Benzene	1.58	0.13	0.54	0.00
Toluene	5.16	0.00	1.21	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-2. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Indolene Fuel

Test 812

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	7.03	4.08
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.49	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	9.81	4.10	5.32	3.46
Ethylene	2.31	0.23	0.73	0.10
Ethane	1.04	1.14	1.27	1.02
Acetylene	0.92	0.00	0.00	0.00
Propane	0.03	0.07	0.05	0.00
Propylene	1.92	0.00	0.76	0.00
Benzene	1.76	0.17	0.58	0.11
Toluene	6.80	0.28	1.40	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-3. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Indolene Fuel

Test 813

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	6.99	2.72
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	9.37	4.16	6.18	4.60
Ethylene	1.77	0.24	0.64	0.21
Ethane	1.00	1.03	1.27	1.05
Acetylene	0.42	0.00	0.00	0.00
Propane	0.16	0.11	0.20	0.03
Propylene	1.74	0.00	0.62	0.00
Benzene	1.53	0.00	0.62	0.14
Toluene	4.46	0.00	1.22	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-4. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Anafuel

Test 821

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.50	2.06
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	2.45	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	7.63	2.12	4.71	2.59
Ethylene	1.87	0.08	0.96	0.04
Ethane	0.44	0.34	0.55	0.39
Acetylene	0.75	0.00	0.00	0.00
Propane	0.12	0.05	0.00	0.00
Propylene	1.17	0.00	0.23	0.00
Benzene	2.19	0.00	0.60	0.08
Toluene	6.78	0.00	1.43	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-5. FTP Individual Sample Unregulated Emissions Results
1981 Ford Escort - Anafuel
Test 822

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.14	1.93
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	7.83	2.10	4.18	2.48
Ethylene	2.01	0.12	0.80	0.15
Ethane	0.50	0.38	0.57	0.41
Acetylene	0.64	0.00	0.00	0.00
Propane	0.09	0.00	0.05	0.00
Propylene	1.04	0.00	0.11	0.00
Benzene	2.16	0.00	0.53	0.00
Toluene	6.68	0.00	1.75	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-6. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Anafuel

Test 823

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.47	2.35
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	7.88	2.06	4.22	2.65
Ethylene	2.22	0.09	0.89	0.05
Ethane	0.45	0.33	0.49	0.35
Acetylene	0.76	0.00	0.00	0.00
Propane	0.01	0.00	0.03	0.02
Propylene	0.99	0.00	0.26	0.00
Benzene	2.60	0.00	0.78	0.00
Toluene	8.16	0.00	2.07	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-7. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel

Test 831

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.75	2.92
Methanol	525.3	106.4
Aldehydes & Ketones		
Formaldehyde	28.91	25.50
Acetaldehyde	0.00	0.00
Acetone	0.94	1.12
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.97	2.83	4.53	2.17
Ethylene	0.10	0.00	0.11	0.00
Ethane	0.03	0.02	0.06	0.01
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.09
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-8. FTP Individual Sample Unregulated Emissions Results
1981 Ford Escort - Methanol Fuel
Test 832

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.82	2.58
Methanol	332.8	88.13
Aldehydes & Ketones		
Formaldehyde	20.03	11.21
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	3.06	2.24	2.49	2.19
Ethylene	0.04	0.00	0.01	0.00
Ethane	0.03	0.00	0.02	0.00
Acetylene	0.07	0.00	0.00	0.00
Propane	0.00	0.08	0.00	0.12
Propylene	0.00	0.00	0.00	0.00
Benzene	0.06	0.00	0.00	0.00
Toluene	0.29	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-9. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel

Test 833

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	6.15	1.54
Methanol	483.0	122.7
Aldehydes & Ketones		
Formaldehyde	30.43	11.30
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.92	1.89	1.81	2.01
Ethylene	0.06	0.00	0.01	0.00
Ethane	0.03	0.02	0.04	0.06
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-10. FTP Individual Sample Unregulated Emissions Results
1981 VW Rabbit - Methanol Fuel
Test 841

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	3.98	1.32
Methanol	743.6	0.00
Aldehydes & Ketones		
Formaldehyde	15.32	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	0.96	0.00	0.01	0.01
Ethylene	0.05	0.00	0.00	0.00
Ethane	0.05	0.00	0.00	0.00
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-11. FTP Individual Sample Unregulated Emissions Results
1981 VW Rabbit - Methanol Fuel
Test 842

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	4.13	2.48
Methanol	647.8	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	0.91	0.01	0.00	0.00
Ethylene	0.05	0.00	0.00	0.00
Ethane	0.01	0.00	0.00	0.00
Acetylene	0.12	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-12. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Methanol Fuel

Test 843

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	3.71	2.65
Methanol	505.8	2.8
Aldehydes & Ketones		
Formaldehyde	12.55	1.33
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	0.94	0.00	0.05	0.00
Ethylene	0.01	0.00	0.00	0.00
Ethane	0.01	0.00	0.00	0.00
Acetylene	0.14	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-13. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Indolene Fuel

Test 851

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	14.52	6.11
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.90	0.19	0.80	0.16
Ethylene	1.69	0.00	0.07	0.00
Ethane	0.52	0.04	0.21	0.01
Acetylene	0.65	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	1.53	0.00	0.00	0.00
Benzene	0.90	0.79	0.28	0.00
Toluene	3.27	0.00	0.50	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-14. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Indolene Fuel

Test 852

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	9.17	6.05
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.38	0.16	1.13	0.07
Ethylene	1.19	0.00	0.18	0.00
Ethane	0.60	0.00	0.26	0.00
Acetylene	0.81	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	1.76	0.00	0.00	0.00
Benzene	0.93	0.79	0.40	0.00
Toluene	3.14	0.00	0.68	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-15. FTP Individual Sample Unregulated Emissions Results
1981 VW Rabbit - Indolene Fuel
Test 853

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	5.95	3.89
Methanol	0.00	0.00
Aldehydes & Ketones		
Formaldehyde	0.00	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.14	0.22	0.74	0.05
Ethylene	1.82	0.00	0.01	0.00
Ethane	0.54	0.05	0.19	0.02
Acetylene	0.74	0.00	0.00	0.00
Propane	0.04	0.00	0.00	0.00
Propylene	1.01	0.00	0.00	0.00
Benzene	1.08	0.00	0.13	0.00
Toluene	3.59	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-16. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Methanol Fuel - Base Metal Catalyst

Test 861

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	--	--
Methanol	995.6	0.00
Aldehydes & Ketones		
Formaldehyde	34.69	24.37
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.03	0.36	0.50	0.51
Ethylene	0.24	0.11	0.21	0.09
Ethane	0.01	0.01	0.02	0.02
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.19	0.00	0.00
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-17. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Methanol Fuel - Base Metal Catalyst

Test 862

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	--	--
Methanol	1046.6	259.7
Aldehydes & Ketones		
Formaldehyde	48.27	21.39
Acetaldehyde	0.00	0.00
Acetone	2.52	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.12	0.35	0.45	0.36
Ethylene	0.29	0.15	0.24	0.14
Ethane	0.00	0.00	0.00	0.00
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-18. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Methanol Fuel - Base Metal Catalyst

Test 863

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	--	--
Methanol	1139.3	345.7
Aldehydes & Ketones		
Formaldehyde	40.68	19.42
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.20	0.21	0.52	0.39
Ethylene	0.26	0.08	0.10	0.02
Ethane	0.03	0.01	0.02	0.01
Acetylene	0.12	0.00	0.00	0.60
Propane	0.17	0.00	0.00	0.00
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-19. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel - Base Metal Catalyst

Test 871

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	3.30	1.86
Methanol	215.6	0.00
Aldehydes & Ketones		
Formaldehyde	5.05	0.00
Acetaldehyde	0.00	0.00
Acetone	0.54	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.85	1.60	1.96	1.69
Ethylene	0.09	0.00	0.01	0.00
Ethane	0.14	0.15	0.23	0.15
Acetylene	0.00	0.00	0.00	0.00
Propane	0.21	0.07	0.00	0.00
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-20. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel - Base Metal Catalyst

Test 872

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	3.62	0.86
Methanol	183.2	21.2
Aldehydes & Ketones		
Formaldehyde	4.10	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	3.10	1.54	1.58	1.27
Ethylene	0.09	0.00	0.00	0.00
Ethane	0.06	0.13	0.18	0.11
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.05	0.12
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-21. FTP Individual Sample Unregulated Emissions Results
1981 Ford Escort - Methanol Fuel - Base Metal Catalyst
Test 873

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	3.49	1.80
Methanol	307.9	0.00
Aldehydes & Ketones		
Formaldehyde	4.66	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	2.56	1.77	1.93	1.24
Ethylene	0.05	0.00	0.00	0.00
Ethane	0.02	0.09	0.13	0.02
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-22. FTP Individual Sample Unregulated Emissions Results
1981 Ford Escort - Methanol Fuel - No Catalyst
Test 881

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	14.87	3.56
Methanol	7346.1	5955.0
Aldehydes & Ketones		
Formaldehyde	--	222.3
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	3.95	2.79	2.95	2.71
Ethylene	0.42	0.28	0.28	0.21
Ethane	0.04	0.02	0.02	0.00
Acetylene	0.30	0.07	0.04	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-23. FTP Individual Sample Unregulated Emissions Results
1981 Ford Escort - Methanol Fuel - No Catalyst
Test 882

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	6.24	4.53
Methanol	9512.8	6330.8
Aldehydes & Ketones		
Formaldehyde	251.02	196.33
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.92
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	4.26	4.08	3.35	3.75
Ethylene	0.45	0.35	0.31	0.28
Ethane	0.06	0.03	0.05	0.03
Acetylene	0.39	0.33	0.28	0.27
Propane	0.27	0.16	0.19	0.28
Propylene	--	--	--	--
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00
Ethanol	0.00	0.00	0.00	0.00

Table C-24. FTP Individual Sample Unregulated Emissions Results

1981 VW Rabbit - Methanol Fuel - Reevaluation Base Metal Catalyst

Test 891

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	4.30	3.23
Methanol	692.6	43.9
Aldehydes & Ketones		
Formaldehyde	46.96	4.41
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.28	0.39	0.62	0.46
Ethylene	0.29	0.09	0.15	0.07
Ethane	0.07	0.07	0.05	0.07
Acetylene	0.00	0.00	0.00	0.00
Propane	0.00	0.00	0.00	0.00
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.00	0.00
Toluene	0.00	0.00	0.00	0.00

Table C-25. FTP Individual Sample Unregulated Emissions Results
1981 VW Rabbit - Methanol Fuel - Reevaluation Base Metal Catalyst
Test 892

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	4.14	2.90
Methanol	740.3	55.10
Aldehydes & Ketones		
Formaldehyde	26.24	11.59
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane	1.22	0.36	0.36	0.18
Ethylene	0.16	0.00	0.06	0.03
Ethane	0.07	0.00	0.05	0.00
Acetylene	0.00	0.00	0.05	0.00
Propane	0.00	0.00	0.44	0.24
Propylene	0.00	0.00	0.00	0.00
Benzene	0.00	0.00	0.22	0.15
Toluene	0.00	0.00	0.00	0.00

Table C-26. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel - New Carburetor

Test 901

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	4.22	1.83
Methanol	425.7	101.1
Aldehydes & Ketones		
Formaldehyde	12.30	9.75
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane				
Ethylene				
Ethane				
Acetylene				
Propane				
Propylene				
Benzene				
Toluene				
Ethanol				

Table C-27. FTP Individual Sample Unregulated Emissions Results

1981 Ford Escort - Methanol Fuel - New Carburetor

Test 902

	Emissions in mg/km	
	Cold-UDDS	Hot-UDDS
Total Particulates	--	--
Methanol	527.8	101.9
Aldehydes & Ketones		
Formaldehyde	23.39	0.00
Acetaldehyde	0.00	0.00
Acetone	0.00	0.00
Methyl ethyl ketone	0.00	0.00
Hexanaldehyde	0.00	0.00

	Emissions in ppm			
	Cold-UDDS		Hot-UDDS	
	1	2	3	4
Individual Hydrocarbons				
Methane				
Ethylene				
Ethane				
Acetylene				
Propane				
Propylene				
Benzene				
Toluene				
Ethanol				

APPENDIX D

COMPUTER PRINTOUTS OF THE REGULATED EMISSIONS TEST RESULTS

Table D-	Test No.	Car	Fuel	Catalyst
1-3	811-3	Escort	Indolene	Noble Metal
4-6	821-3	Escort	Anafuel	Noble Metal
7-9	831-3	Escort	Methanol	Noble Metal
10-12	841-3	Rabbit	Methanol	Noble Metal
13-15	851-3	Rabbit	Indolene	Noble Metal
16-18	861-3	Rabbit	Methanol	Promoted Base Metal
19-21	871-3	Escort	Methanol	Promoted Base Metal
22-23	881-2	Escort	Methanol	None
24-25	891-2	Rabbit	Methanol	Promoted Base Metal
26-27	901-2	Escort	Methanol	Noble Metal

TABLE D-1. TEST NO. 811 EMISSIONS RESULTS

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                                      FTP    VEHICLE EMISSIONS RESULTS
                                              PROJECT 05-5830-011

TEST NO.   811FTP   RUN   1                   VEHICLE NO.81                       TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                DATE    7/ 7/81                     ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                    BAG CART NO. 1 / CVS NO.  2         GASOLINE  EM-338-F
TRANSMISSION M4                               DYNO NO.     3                      ODOMETER  7891. KM( 4903. MILES)

BAROMETER 740.41 MM HG(29.15 IN HG)           DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  63. PCT                    ABS. HUMIDITY 12.4 GM/KG            NOX HUMIDITY CORRECTION FACTOR  1.06
BAG RESULTS
   BAG NUMBER                                        1                  2                 3                   4
   DESCRIPTION                                COLD TRANSIENT       STABILIZED       HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)       787.4 (31.0)       774.7 (30.5)       774.7 (30.5)
   BLOWER INLET P MM. H2O(IN. H2O)            774.7 (30.5)       774.7 (30.5)       762.0 (30.0)       764.5 (30.1)
   BLOWER INLET TEMP. DEG. C(DEG. F)           40.6 (105.0)       40.6 (105.0)       42.2 (108.0)       42.2 (108.0)
   BLOWER REVOLUTIONS                            40484.             69443.             40431.             69400.
   TOT FLOW STD. CU. METRES(SCF)               75.7 ( 2674.)      129.9 ( 4586.)      75.5 ( 2667.)     129.6 ( 4576.)
   HC  SAMPLE METER/RANGE/PPM                 70.4/ 2/  70.      19.5/ 2/  20.      33.8/ 2/  34.      17.6/ 2/  18.
   HC  BCKGRD METER/RANGE/PPM                  9.3/ 2/   9.       7.6/ 2/   8.       7.5/ 2/   8.       6.9/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                 97.4/11/ 510.      30.2/13/  28.      87.6/12/ 213.      32.3/13/  30.
   CO  BCKGRD METER/RANGE/PPM                  1.1/11/   3.       2.1/13/   2.        .9/12/   2.       1.6/13/   1.
   CO2 SAMPLE METER/RANGE/PCT                 57.9/ 3/ 1.02      38.3/ 3/  .65      49.6/ 3/  .86      37.8/ 3/  .64
   CO2 BCKGRD METER/RANGE/PCT                  3.2/ 3/  .05       3.3/ 3/  .05       3.1/ 3/  .05       2.9/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                 17.1/ 2/  17.       8.2/ 2/   8.      11.5/ 2/  12.       7.7/ 2/   8.
   NOX BCKGRD METER/RANGE/PPM                   .1/ 2/   0.        .1/ 2/   0.        .5/ 2/   1.        .5/ 2/   1.
   DILUTION FACTOR                                12.44              20.59              15.17              20.88
   HC  CONCENTRATION PPM                          62.                12.                27.                11.
   CO  CONCENTRATION PPM                         486.                25.               204.                27.
   CO2 CONCENTRATION PCT                          .98                .60                .82                .59
   NOX CONCENTRATION PPM                         17.0                8.1               11.0                7.2
   HC  MASS GRAMS                                 2.70               .92               1.17                .82
   CO  MASS GRAMS                                42.88              3.79              17.93               4.14
   CO2 MASS GRAMS                              1353.4             1422.3             1127.0             1411.2
   NOX MASS GRAMS                                 2.61              2.13               1.69               1.90

   HC  GRAMS/KM                                    .46               .15                .20                .13
   CO  GRAMS/KM                                   7.36               .60               3.10                .67
   CO2 GRAMS/KM                                 232.4              226.5              194.6              227.1
   NOX GRAMS/KM                                    .45               .34                .29                .31
   FUEL CONSUMPTION BY CB L/100KM                10.48              9.73               8.54               9.75

   RUN TIME              SECONDS                505.               868.               505.               868.
   MEASURED DISTANCE     KM                     5.82               6.28               5.79               6.21
   SCF, DRY                                     .970               .974               .972               .974
         DFC, WET (DRY)                               .940 ( .921)                          .945 ( .926)
         SCF, WET (DRY)                              1.000 ( .972)                         1.000 ( .973)
         VOL (SCM)                                          205.6                                 205.1
         SAM BLR (SCM)                                       0.00                                  0.00
         KM  (MEASURED)                                     12.10                                 12.01
         FUEL CONSUMPTION L/100KM                           10.09                                  9.17

COMPOSITE RESULTS                                                                              3-BAG       (4-BAG)
   TEST NUMBER          811FTP                                       CARBON DIOXIDE      G/KM     219.0      ( 219.1)
   BAROMETER    MM HG  740.4                                         FUEL CONSUMPTION    L/100KM    9.56      (  9.56)
   HUMIDITY     G/KG    12.4                                         HYDROCARBONS (THC)  G/KM       .23      (   .22)
   TEMPERATURE  DEG C   24.4                                         CARBON MONOXIDE     G/KM      2.68      (  2.71)
                                                                     OXIDES OF NITROGEN  G/KM       .35      (   .34)
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                                      HFET   VEHICLE EMISSIONS RESULTS
                                              PROJECT 05-5830-011

  TEST NO.   811FET   RUN   1                  VEHICLE NO.81
  VEHICLE MODEL   81 FORD ESCORT               DATE    7/ 7/81                   TEST WEIGHT  1134. KG( 2500. LBS)
  ENGINE 1.6 L( 98. CID) L-4                   BAG CART NO.  1                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
  TRANSMISSION M4                              DYNO NO.      3                   GASOLINE  EM-338-F
                                               CVS NO.   2                       ODOMETER  7915. KM( 4918. MILES)

  BAROMETER 740.16 MM HG(29.14 IN HG)          DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
  RELATIVE HUMIDITY  64. PCT                   ABS. HUMIDITY 14.0 GM/KG          NOX HUMIDITY CORRECTION FACTOR  1.12
0 BAG RESULTS
     TEST CYCLE                                     HFET

     BLOWER DIF P MM. H2O(IN. H2O)             787.4 (31.0)
     BLOWER INLET P MM. H2O(IN. H2O)           777.2 (30.6)
     BLOWER INLET TEMP. DEG. C(DEG. F)          41.7 (107.0)
     BLOWER REVOLUTIONS                            61287.
     TOT FLOW STD. CU. METRES(SCF)             114.3 ( 4037.)
     HC  SAMPLE METER/RANGE/PPM                31.8/ 2/  32.
     HC  BCKGRD METER/RANGE/PPM                 7.5/ 2/   8.
     CO  SAMPLE METER/RANGE/PPM                78.5/12/ 184.
     CO  BCKGRD METER/RANGE/PPM                  .6/12/   1.
     CO2 SAMPLE METER/RANGE/PCT                67.0/ 3/ 1.20
     CO2 BCKGRD METER/RANGE/PCT                 3.4/ 3/  .05
     NOX SAMPLE METER/RANGE/PPM                20.0/ 2/  20.
     NOX BCKGRD METER/RANGE/PPM                  .4/ 2/   0.
     DILUTION FACTOR                              10.95
     HC  CONCENTRATION PPM                        25.
     CO  CONCENTRATION PPM                       175.
     CO2 CONCENTRATION PCT                        1.16
     NOX CONCENTRATION PPM                       19.6
     HC  MASS GRAMS                                1.65
     CO  MASS GRAMS                               23.34
     CO2 MASS GRAMS                             2419.9
     NOX MASS GRAMS                                4.82
     RUN TIME                 SECONDS            766.
          DFC, WET (DRY)                       .909 ( .890)
          SCF, WET (DRY)                      1.000 ( .968)
          VOL (SCM)                              114.3
          SAM BLR (SCM)                            0.00
          KM  (MEASURED)                          16.51

     TEST NUMBER,                                811FET
     BAROMETER,               MM HG              740.2
     HUMIDITY,                G/KG                14.0
     TEMPERATURE,             DEG C               26.1
      CARBON DIOXIDE,          G/KM              146.5
     FUEL CONSUMPTION,        L/100KM              6.36

     HYDROCARBONS,            G/KM                 .10
     CARBON MONOXIDE,         G/KM                1.41
     OXIDES OF NITROGEN,      G/KM                 .29
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TABLE D-2. TEST NO. 812 EMISSIONS RESULTS

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                                                 FTP    VEHICLE EMISSIONS RESULTS
                                                         PROJECT 05-5830-011

 TEST NO.   812FTP   RUN   1                         VEHICLE NO.81                          TEST WEIGHT  1134. KG( 2500. LBS)
 VEHICLE MODEL   81 FORD ESCORT                      DATE    7/ 8/81                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
 ENGINE 1.6 L( 98. CID) L-4                          BAG CART NO. 1 / CVS NO.  2            GASOLINE  EM-338-F
 TRANSMISSION M4                                     DYNO NO.      3                        ODOMETER  7932. KM( 4929. MILES)

 BAROMETER 744.98 MM HG(29.33 IN HG)                 DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
 RELATIVE HUMIDITY  59. PCT                          ABS. HUMIDITY 11.1 GM/KG               NOX HUMIDITY CORRECTION FACTOR  1.01
 BAG RESULTS
    BAG NUMBER                                        1                   2                   3                    4
    DESCRIPTION                                 COLD TRANSIENT       STABILIZED       HOT TRANSIENT        STABILIZED

    BLOWER DIF P MM. H2O(IN. H2O)               800.1 (31.5)        787.4 (31.0)       787.4 (31.0)        784.9 (30.9)
    BLOWER INLET P MM. H2O(IN. H2O)             787.4 (31.0)        774.7 (30.5)       774.7 (30.5)        769.6 (30.3)
    BLOWER INLET TEMP. DEG. C(DEG. F)            42.2 (108.0)        42.2 (108.0)       41.7 (107.0)        42.2 (108.0)
    BLOWER REVOLUTIONS                             40438.              69408.             40417.              69267.
    TOT FLOW STD. CU. METRES(SCF)                75.8 ( 2676.)      130.3 ( 4602.)      76.0 ( 2682.)      130.1 ( 4595.)
    HC  SAMPLE METER/RANGE/PPM                  81.1/ 2/  81.       22.3/ 2/  22.      38.7/ 2/  39.       20.8/ 2/  21.
    HC  BCKGRD METER/RANGE/PPM                  11.1/ 2/  11.       10.6/ 2/  11.       9.9/ 2/  10.       10.0/ 2/  10.
    CO  SAMPLE METER/RANGE/PPM                  26.0/ 3/ 603.       40.7/13/  38.      64.4/11/ 261.       32.9/13/  30.
    CO  BCKGRD METER/RANGE/PPM                    .4/ 3/   9.        7.2/13/   6.       1.7/11/   5.        4.8/13/   4.
    CO2 SAMPLE METER/RANGE/PCT                  57.5/ 3/ 1.01       40.2/ 3/  .68      50.9/ 3/  .88       39.3/ 3/  .66
    CO2 BCKGRD METER/RANGE/PCT                   2.9/ 3/  .04        3.4/ 3/  .05       3.3/ 3/  .05        3.3/ 3/  .05
    NOX SAMPLE METER/RANGE/PPM                  20.9/ 2/  21.        8.3/ 2/   8.      13.2/ 2/  13.        9.6/ 2/  10.
    NOX BCKGRD METER/RANGE/PPM                    .3/ 2/   0.         .2/ 2/   0.        .4/ 2/   0.         .4/ 2/   0.
    DILUTION FACTOR                                 12.41               19.50              14.67               20.01
    HC  CONCENTRATION PPM                           71.                 12.                29.                 11.
    CO  CONCENTRATION PPM                          572.                 31.               247.                 25.
    CO2 CONCENTRATION PCT                            .97                 .63                .84                 .62
    NOX CONCENTRATION PPM                          20.6                 8.1               12.8                 9.2
    HC  MASS GRAMS                                  3.10                 .92               1.29                 .85
    CO  MASS GRAMS                                 50.48                4.65              21.85                3.84
    CO2 MASS GRAMS                               1349.6              1508.0             1164.6              1469.3
    NOX MASS GRAMS                                  3.03                2.05               1.89                2.32

    HC  GRAMS/KM                                     .53                 .14                .22                 .13
    CO  GRAMS/KM                                    8.67                 .72               3.69                 .60
    CO2 GRAMS/KM                                  231.9               233.9              196.6               227.9
    NOX GRAMS/KM                                     .52                 .32                .32                 .36
    FUEL CONSUMPTION BY CB L/100KM                 10.55               10.05               8.67                9.78

    RUN TIME             SECONDS                   505.                867.               505.                866.
    MEASURED DISTANCE    KM                        5.82                6.45               5.92                6.45
    SCF, DRY                                       .972                .975               .973                .975
         DFC, WET (DRY)                                      .938 ( .920)                          .943 ( .925)
         SCF, WET (DRY)                                     1.000 ( .974)                         1.000 ( .974)
         VOL (SCM)                                                 206.1                                 206.1
         SAM BLR (SCM)                                              0.00                                  0.00
         KM  (MEASURED)                                            12.27                                 12.37
         FUEL CONSUMPTION L/100KM                                  10.29                                  9.25

COMPOSITE RESULTS
    TEST NUMBER          812FTP                                                                   3-BAG        (4-BAG)
    BAROMETER    MM HG   745.0                                  CARBON DIOXIDE       G/KM         223.3       ( 221.5)
    HUMIDITY     G/KG     11.1                                  FUEL CONSUMPTION     L/100KM       9.78       (  9.70)
    TEMPERATURE  DEG C    23.9                                  HYDROCARBONS (THC)   G/KM           .24       (   .24)
                                                                CARBON MONOXIDE      G/KM          3.15       (  3.12)
                                                                OXIDES OF NITROGEN   G/KM           .36       (   .37)



                                                 HFET   VEHICLE EMISSIONS RESULTS
                                                         PROJECT 05-5830-011

 TEST NO.   812FET   RUN   1                         VEHICLE NO.81
 VEHICLE MODEL   81 FORD ESCORT                      DATE    7/ 8/81                        TEST WEIGHT  1134. KG( 2500. LBS)
 ENGINE 1.6 L( 98. CID) L-4                          BAG CART NO.  1                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
 TRANSMISSION M4                                     DYNO NO.      3                        GASOLINE  EM-338-F
                                                     CVS NO.   2                            ODOMETER  7971. KM( 4953. MILES)

 BAROMETER 744.98 MM HG(29.33 IN HG)                 DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
 RELATIVE HUMIDITY  55. PCT                          ABS. HUMIDITY 10.4 GM/KG               NOX HUMIDITY CORRECTION FACTOR   .99
0BAG RESULTS
    TEST CYCLE                                           HFET

    BLOWER DIF P MM. H2O(IN. H2O)               779.8 (30.7)
    BLOWER INLET P MM. H2O(IN. H2O)             764.5 (30.1)
    BLOWER INLET TEMP. DEG. C(DEG. F)            41.1 (106.0)
    BLOWER REVOLUTIONS                             61240.
    TOT FLOW STD. CU. METRES(SCF)               115.3 ( 4073.)
    HC  SAMPLE METER/RANGE/PPM                  36.7/ 2/  37.
    HC  BCKGRD METER/RANGE/PPM                   9.7/ 2/  10.
    CO  SAMPLE METER/RANGE/PPM                  50.1/12/ 106.
    CO  BCKGRD METER/RANGE/PPM                   1.4/12/   3.
    CO2 SAMPLE METER/RANGE/PCT                  65.6/ 3/ 1.18
    CO2 BCKGRD METER/RANGE/PCT                   3.2/ 3/  .05
    NOX SAMPLE METER/RANGE/PPM                  27.4/ 2/  27.
    NOX BCKGRD METER/RANGE/PPM                   1.0/ 2/   1.
    DILUTION FACTOR                                 11.27
    HC  CONCENTRATION PPM                           28.
    CO  CONCENTRATION PPM                          100.
    CO2 CONCENTRATION PCT                           1.13
    NOX CONCENTRATION PPM                          26.5
    HC  MASS GRAMS                                  1.85
    CO  MASS GRAMS                                 13.37
    CO2 MASS GRAMS                               2387.0
    NOX MASS GRAMS                                  5.78
    RUN TIME                 SECONDS               766.
         DFC, WET (DRY)                        .911 ( .895)
         SCF, WET (DRY)                       1.000 ( .971)
         VOL (SCM)                                115.3
         SAM BLR (SCM)                             0.00
         KM  (MEASURED)                           16.66

    TEST NUMBER,                                 812FET
    BAROMETER,               MM HG                745.0
    HUMIDITY,                G/KG                  10.4
    TEMPERATURE,             DEG C                 23.9
     CARBON DIOXIDE,          G/KM                143.3
    FUEL CONSUMPTION,        L/100KM               6.18

    HYDROCARBONS,            G/KM                   .11
    CARBON MONOXIDE,         G/KM                   .80
    OXIDES OF NITROGEN,      G/KM                   .35
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TEST D-3. TEST NO. 813 EMISSIONS RESULTS

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                                    FTP    VEHICLE EMISSIONS RESULTS
                                            PROJECT 05-5830-011

TEST NO.   813FTP   RUN   1                    VEHICLE NO.81                     TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                 DATE    7/ 9/81                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                     BAG CART NO. 1 / CVS NO.  2       GASOLINE  EM338-F
TRANSMISSION M4                                DYNO NO.      3                   ODOMETER  7994. KM( 4967. MILES)

BAROMETER 745.74 MM HG(29.36 IN HG)            DRY BULB TEMP. 23.3 DEG C(74.0 DEG F)
RELATIVE HUMIDITY  54. PCT                     ABS. HUMIDITY  9.9 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .97
BAG RESULTS
   BAG NUMBER                                       1                 2                  3                  4
   DESCRIPTION                                COLD TRANSIENT      STABILIZED        HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              795.0 (31.3)      789.9 (31.1)       789.9 (31.1)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)            787.4 (31.0)      779.8 (30.7)       779.8 (30.7)       774.7 (30.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)          41.7 (107.0)       42.2 (108.0)      42.2 (108.0)        42.2 (108.0)
   BLOWER REVOLUTIONS                            40496.             69489.            40408.             69447.
   TOT FLOW STD. CU. METRES(SCF)              76.0 ( 2682.)     130.4 ( 4604.)     79.8 ( 2677.)     130.4 ( 4604.)
   HC   SAMPLE METER/RANGE/PPM                72.0/ 2/  72.      19.9/ 2/  20.     35.7/ 2/  36.      20.3/ 2/  20.
   HC   BCKGRD METER/RANGE/PPM                 9.3/ 2/   9.       9.0/ 2/   9.      9.5/ 2/  10.       8.6/ 2/   9.
   CO   SAMPLE METER/RANGE/PPM                93.0/11/ 468.      28.6/13/  26.     87.6/12/ 213.      49.7/13/  47.
   CO   BCKGRD METER/RANGE/PPM                  .5/11/   1.       1.3/13/   1.       .7/12/   1.       1.4/13/   1.
   CO2 SAMPLE METER/RANGE/PCT                 56.6/ 3/ 1.00      39.1/ 3/  .66     48.6/ 3/  .84      38.3/ 3/  .65
   CO2 BCKGRD METER/RANGE/PCT                  3.2/ 3/  .05       3.6/ 3/  .06      3.1/ 3/  .05       3.4/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                 16.5/ 2/  17.       8.1/ 2/   8.     12.0/ 2/  12.       8.0/ 2/   8.
   NOX BCKGRD METER/RANGE/PPM                   .1/ 2/   0.        .2/ 2/   0.       .1/ 2/   0.        .1/ 2/   0.
   DILUTION FACTOR                               12.79              20.13             15.50              20.53
   HC   CONCENTRATION PPM                         63.                11.               27.                12.
   CO   CONCENTRATION PPM                        450.                24.              205.                44.
   CO2 CONCENTRATION PCT                          .95                .61               .80                .60
   NOX CONCENTRATION PPM                         16.4                7.9              11.9                7.9
   HC   MASS GRAMS                               2.78                .85              1.17                .91
   CO   MASS GRAMS                              39.76               3.70             18.09               6.72
   CO2 MASS GRAMS                              1322.0             1452.7            1104.6             1424.3
   NOX MASS GRAMS                                2.32               1.92              1.68               1.92

   HC   GRAMS/KM                                  .48                .13               .20                .14
   CO   GRAMS/KM                                 6.84                .58              3.06               1.05
   CO2 GRAMS/KM                                 227.3              227.0             186.9              221.6
   NOX GRAMS/KM                                   .40                .30               .28                .30
   FUEL CONSUMPTION BY CB L/100KM               10.23               9.74              8.21               9.55

   RUN TIME              SECONDS                 505.               868.              505.               868.
   MEASURED DISTANCE     KM                      5.82               6.40              5.91               6.43
   SCF, DRY                                      .975               .976              .975               .976
        DFC, WET (DRY)                                  .940 ( .923)                          .945 ( .929)
        SCF, WET (DRY)                                 1.000 ( .975)                         1.000 ( .976)
        VOL (SCM)                                            206.3                                 206.2
        SAM BLR (SCM)                                         0.00                                  0.00
        KM  (MEASURED)                                       12.22                                 12.34
        FUEL CONSUMPTION L/100KM                              9.97                                  8.91

COMPOSITE RESULTS                                                                                3-BAG       (4-BAG)
   TEST NUMBER            813FTP                        CARBON DIOXIDE        G/KM      216.1       ( 214.5)
   BAROMETER     MM HG   745.7                          FUEL CONSUMPTION      L/100KM     9.42       (  9.37)
   HUMIDITY      G/KG      9.9                          HYDROCARBONS (THC)    G/KM        .22       (   .22)
   TEMPERATURE   DEG C    23.3                          CARBON MONOXIDE       G/KM       2.54       (  2.68)
                                                        OXIDES OF NITROGEN    G/KM        .32       (   .32)
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                                    HFET   VEHICLE EMISSIONS RESULTS
                                            PROJECT 05-5830-011

  TEST NO.   813FET   RUN   1                  VEHICLE NO.81                     TEST WEIGHT  1134. KG( 2500. LBS)
  VEHICLE MODEL   81 FORD ESCORT               DATE    7/ 9/81                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
  ENGINE 1.6 L( 98. CID) L-4                   BAG CART NO.  1                   GASOLINE  EM-338-F
  TRANSMISSION M4                              DYNO NO.      3                   ODOMETER  8018. KM( 4982. MILES)
                                               CVS NO.   2

  BAROMETER 746.00 MM HG(29.37 IN HG)          DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
  RELATIVE HUMIDITY  50. PCT                   ABS. HUMIDITY 10.9 GM/KG          NOX HUMIDITY CORRECTION FACTOR  1.00
0 BAG RESULTS
     TEST CYCLE                                    HFET

     BLOWER DIF P MM. H2O(IN. H2O)             792.5 (31.2)
     BLOWER INLET P MM. H2O(IN. H2O)           777.2 (30.6)
     BLOWER INLET TEMP. DEG. C(DEG. F)          42.2 (108.0)
     BLOWER REVOLUTIONS                           61186.
     TOT FLOW STD. CU. METRES(SCF)             114.9 ( 4056.)
     HC   SAMPLE METER/RANGE/PPM               31.6/ 2/  32.
     HC   BCKGRD METER/RANGE/PPM                8.9/ 2/   9.
     CO   SAMPLE METER/RANGE/PPM               56.7/12/ 123.
     CO   BCKGRD METER/RANGE/PPM                 .7/12/   1.
     CO2 SAMPLE METER/RANGE/PCT                65.1/ 3/ 1.16
     CO2 BCKGRD METER/RANGE/PCT                 3.0/ 3/  .05
     NOX SAMPLE METER/RANGE/PPM                21.5/ 2/  22.
     NOX BCKGRD METER/RANGE/PPM                  .3/ 2/   0.
     DILUTION FACTOR                              11.36
     HC   CONCENTRATION PPM                        23.
     CO   CONCENTRATION PPM                       117.
     CO2 CONCENTRATION PCT                        1.12
     NOX CONCENTRATION PPM                        21.2
     HC   MASS GRAMS                              1.56
     CO   MASS GRAMS                             15.64
     CO2 MASS GRAMS                             2361.7
     NOX MASS GRAMS                               4.68
     RUN TIME              SECONDS                765.
          DFC, WET (DRY)                       .912 ( .897)
          SCF, WET (DRY)                      1.000 ( .973)
          VOL (SCM)                              114.9
          SAM BLR (SCM)                           0.00
          KM  (MEASURED)                         16.63

     TEST NUMBER,                               813FET
     BAROMETER,              MM HG               746.0
     HUMIDITY,               G/KG                 10.9
     TEMPERATURE,            DEG C                26.1
      CARBON DIOXIDE,         G/KM               142.1
     FUEL CONSUMPTION,       L/100KM              6.14

     HYDROCARBONS,           G/KM                  .09
     CARBON MONOXIDE,        G/KM                  .94
     OXIDES OF NITROGEN,     G/KM                  .28
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TABLE D-4. TEST NO. 821 EMISSIONS RESULTS

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                                             FTP    VEHICLE EMISSIONS RESULTS
                                                      PROJECT 09-9830-011

TEST NO.   821FTP   RUN   1                      VEHICLE NO.82                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE    7/13/81                            ACTUAL ROAD LOAD   9.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO. 1 / CVS NO.  2                GASOLINE  EM-479-F
TRANSMISSION M4                                  DYNO NO.      3                            ODOMETER  8082. KM( 5022. MILES)

BAROMETER 743.71 MM HG(29.28 IN HG)              DRY BULB TEMP. 23.3 DEG C(74.0 DEG F)
RELATIVE HUMIDITY  62. PCT                       ABS. HUMIDITY 11.4 GM/KG                   NOX HUMIDITY CORRECTION FACTOR  1.02
BAG RESULTS
  BAG NUMBER                                           1                      2                      3                      4
  DESCRIPTION                                  COLD TRANSIENT            STABILIZED          HOT TRANSIENT            STABILIZED

  BLOWER DIF P MM. H2O(IN. H2O)                792.5 (31.2)           789.0 (31.1)           774.7 (30.5)           777.2 (30.6)
  BLOWER INLET P MM. H2O(IN. H2O)              784.9 (30.9)           779.8 (30.7)           787.4 (31.0)           787.4 (31.0)
  BLOWER INLET TEMP. DEG. C(DEG. F)             42.2 (108.0)           42.2 (108.0)           42.2 (108.0)           42.2 (108.0)
  BLOWER REVOLUTIONS                              40487.                 69452.                 40402.                 69433.
  TOT FLOW STD. CU. METRES(SCF)                 75.8 ( 2675.)         130.0 ( 4592.)          75.6 ( 2670.)         129.9 ( 4588.)
  HC  SAMPLE METER/RANGE/PPM                   67.4/ 2/  67.          12.9/ 2/  13.          28.4/ 2/  28.          14.0/ 2/  14.
  HC  BCKGRD METER/RANGE/PPM                    8.8/ 2/   9.           7.7/ 2/   8.           7.5/ 2/   8.           7.0/ 2/   7.
  CO  SAMPLE METER/RANGE/PPM                   89.5/11/ 437.          18.7/13/  17.          56.5/12/ 122.          36.6/13/  34.
  CO  BCKGRD METER/RANGE/PPM                    2.6/11/   8.           6.9/13/   6.           2.6/12/   5.           4.5/13/   4.
  CO2 SAMPLE METER/RANGE/PCT                   98.1/ 3/ 1.03          39.1/ 3/  .66          50.5/ 3/  .88          38.2/ 3/  .64
  CO2 BCKGRD METER/RANGE/PCT                    3.5/ 3/  .05           3.5/ 3/  .05           3.8/ 3/  .06           3.2/ 3/  .05
  NOX SAMPLE METER/RANGE/PPM                   18.4/ 2/  18.          10.5/ 2/  11.          18.2/ 2/  18.           9.8/ 2/  10.
  NOX BCKGRD METER/RANGE/PPM                     .9/ 2/   1.            .9/ 2/   1.            .8/ 2/   1.            .4/ 2/   0.
  DILUTION FACTOR                                  12.48                  20.18                  15.03                  20.64
  HC  CONCENTRATION PPM                              59.                     6.                    21.                     7.
  CO  CONCENTRATION PPM                             413.                    11.                   113.                    29.
  CO2 CONCENTRATION PCT                              .98                    .61                    .82                    .60
  NOX CONCENTRATION PPM                             17.6                    9.6                   17.5                    9.4
  HC  MASS GRAMS                                    2.59                    .42                    .93                    .95
  CO  MASS GRAMS                                   36.43                   1.61                   9.98                   4.39
  CO2 MASS GRAMS                                  1393.7                 1452.4                 1138.6                 1422.1
  NOX MASS GRAMS                                    2.60                   2.49                   2.58                   2.39

  HC  GRAMS/KM                                       .49                    .07                    .16                    .09
  CO  GRAMS/KM                                      6.29                    .25                   1.69                    .68
  CO2 GRAMS/KM                                     233.5                  226.2                  192.7                  221.4
  NOX GRAMS/KM                                       .45                    .38                    .44                    .37
  FUEL CONSUMPTION BY CB L/100KM                   10.45                   9.68                   8.36                   9.51

  RUN TIME                   SECONDS                505.                   868.                   505.                   868.
  MEASURED DISTANCE          KM                     9.80                   6.42                   5.91                   6.42
  SCF, DRY                                          .971                   .974                   .972                   .974
      DFC, WET (DRY)                                       .939 ( .920)                   .945 ( .926)
      SCF, WET (DRY)                                      1.000 ( .973)                  1.000 ( .973)
      VOL (SCM)                                                 205.8                          205.6
      SAM BLR (SCM)                                              0.00                           0.00
      KM  (MEASURED)                                            12.22                          12.33
      FUEL CONSUMPTION L/100KM                                  10.04                           8.96

COMPOSITE RESULTS
    TEST NUMBER            821FTP
    BAROMETER      MM HG   743.7                                                                     3-BAG        (4-BAG)
    HUMIDITY       G/KG     11.4                     CARBON DIOXIDE          G/KM                   218.5        ( 217.1)
    TEMPERATURE    DEG C    23.3                     FUEL CONSUMPTION        L/100KM                 9.61        (   9.59
                                                     HYDROCARBONS (THC)      G/KM                     .18        (    .18
                                                     CARBON MONOXIDE         G/KM                    1.87        (   2.00)
                                                     OXIDES OF NITROGEN      G/KM                     .41        (    .41)


                                             HFET   VEHICLE EMISSIONS RESULTS
                                                      PROJECT 09-9830-011

TEST NO.   821FET   RUN   1                      VEHICLE NO.82                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE    7/13/81                            ACTUAL ROAD LOAD   9.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO.  1                            GASOLINE  EM-479-F
TRANSMISSION M4                                  DYNO NO.      3                            ODOMETER  8108. KM( 5038. MILES)
                                                 CVS NO.   2

BAROMETER 743.71 MM HG(29.28 IN HG)              DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  50. PCT                       ABS. HUMIDITY 10.4 GM/KG                   NOX HUMIDITY CORRECTION FACTOR   .99
0 BAG RESULTS
   TEST CYCLE                                       HFET

  BLOWER DIF P MM. H2O(IN. H2O)                787.4 (31.0)
  BLOWER INLET P MM. H2O(IN. H2O)              774.7 (30.5)
  BLOWER INLET TEMP. DEG. C(DEG. F)             42.2 (108.0)
  BLOWER REVOLUTIONS                              61274.
  TOT FLOW STD. CU. METRES(SCF)                114.8 ( 4053.)
  HC  SAMPLE METER/RANGE/PPM                   20.3/ 2/  20.
  HC  BCKGRD METER/RANGE/PPM                    7.0/ 2/   7.
  CO  SAMPLE METER/RANGE/PPM                   90.9/12/ 108.
  CO  BCKGRD METER/RANGE/PPM                    1.8/12/   3.
  CO2 SAMPLE METER/RANGE/PCT                   68.5/ 3/ 1.23
  CO2 BCKGRD METER/RANGE/PCT                    3.8/ 3/  .06
  NOX SAMPLE METER/RANGE/PPM                   29.8/ 2/  30.
  NOX BCKGRD METER/RANGE/PPM                     .3/ 2/   0.
  DILUTION FACTOR                                  10.75
  HC  CONCENTRATION PPM                              14.
  CO  CONCENTRATION PPM                             101.
  CO2 CONCENTRATION PCT                             1.18
  NOX CONCENTRATION PPM                             29.5
  HC  MASS GRAMS                                     .92
  CO  MASS GRAMS                                   13.48
  CO2 MASS GRAMS                                  2481.6
  NOX MASS GRAMS                                    6.42
  RUN TIME                   SECONDS                766.
      DFC, WET (DRY)                              .907 ( .892)
      SCF, WET (DRY)                             1.000 ( .973)
      VOL (SCM)                                     114.8
      SAM BLR (SCM)                                  0.00
      KM  (MEASURED)                                16.74

  TEST NUMBER,                                    821FET
  BAROMETER,               MM HG                   743.7
  HUMIDITY,                G/KG                     10.4
  TEMPERATURE,             DEG C                    25.6
   CARBON DIOXIDE,          G/KM                   148.2
  FUEL CONSUMPTION,        L/100KM                  6.48

  HYDROCARBONS,            G/KM                      .06
  CARBON MONOXIDE,         G/KM                      .80
  OXIDES OF NITROGEN,      G/KM                      .38
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TABLE D-5. TEST NO. 822 EMISSIONS RESULTS

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                                   FTP    VEHICLE EMISSIONS RESULTS
                                            PROJECT 05-5830-011

TEST NO.   822FTP   RUN   1               VEHICLE NO.82                          TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT            DATE    7/14/81                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                BAG CART NO. 1 / CVS NO.  2            GASOLINE  EM-479-F
TRANSMISSION M4                           DYNO NO.      3                        ODOMETER  8126. KM( 5049. MILES)

BAROMETER 742.70 MM HG(29.24 IN HG)       DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  78. PCT                ABS. HUMIDITY 15.0 GM/KG               NOX HUMIDITY CORRECTION FACTOR  1.16
BAG RESULTS
  BAG NUMBER                                    1                 2                   3                   4
  DESCRIPTION                            COLD TRANSIENT       STABILIZED       HOT TRANSIENT          STABILIZED

  BLOWER DIF P MM. H2O(IN. H2O)           810.3 (31.9)       784.9 (30.9)      777.2 (30.6)        774.7 (30.5)
  BLOWER INLET P MM. H2O(IN. H2O)         800.1 (31.5)       774.7 (30.5)      767.1 (30.2)        764.5 (30.1)
  BLOWER INLET TEMP. DEG. C(DEG. F)        35.6 ( 96.0)       42.2 (108.0)      41.7 (107.0)        42.2 (108.0)
  BLOWER REVOLUTIONS                         40686.             69464.            40459.              69380.
  TOT FLOW STD. CU. METRES(SCF)            76.8 ( 2714.)     130.0 ( 4589.)     75.9 ( 2678.)      130.0 ( 4590.)
  HC  SAMPLE METER/RANGE/PPM              65.4/ 2/  65.      10.8/ 2/  11.     29.0/ 2/  29.       11.7/ 2/  12.
  HC  BCKGRD METER/RANGE/PPM               6.8/ 2/   7.       6.0/ 2/   6.      5.8/ 2/   6.        6.0/ 2/   6.
  CO  SAMPLE METER/RANGE/PPM              93.8/11/ 475.       9.6/13/   9.     59.5/12/ 130.       25.6/13/  23.
  CO  BCKGRD METER/RANGE/PPM                .4/11/   1.       1.0/13/   1.       .6/12/   1.        1.2/13/   1.
  CO2 SAMPLE METER/RANGE/PCT              59.1/ 3/ 1.05      37.5/ 3/  .63     48.8/ 3/  .84       36.7/ 3/  .62
  CO2 BCKGRD METER/RANGE/PCT               3.1/ 3/  .05       2.7/ 3/  .04      2.9/ 3/  .04        3.7/ 3/  .06
  NOX SAMPLE METER/RANGE/PPM              16.6/ 2/  17.       9.2/ 2/   9.     19.0/ 2/  19.        9.7/ 2/  10.
  NOX BCKGRD METER/RANGE/PPM                .4/ 2/   0.        .3/ 2/   0.       .5/ 2/   1.         .6/ 2/   1.
  DILUTION FACTOR                            12.21              21.16             15.59               21.61
  HC  CONCENTRATION PPM                      59.                 9.               24.                  6.
  CO  CONCENTRATION PPM                     453.                 8.              124.                 22.
  CO2 CONCENTRATION PCT                      1.00               .59               .80                 .56
  NOX CONCENTRATION PPM                      16.2               8.9               18.5                 9.1
  HC  MASS GRAMS                             2.62               .38               1.03                 .45
  CO  MASS GRAMS                            40.51              1.14              10.93                3.26
  CO2 MASS GRAMS                           1409.1            1408.9             1114.5              1339.1
  NOX MASS GRAMS                             2.77              2.98               3.13                2.64

  HC  GRAMS/KM                                .45               .06                .18                 .07
  CO  GRAMS/KM                               7.01               .18               1.87                 .52
  CO2 GRAMS/KM                              243.7             224.2              190.4               212.9
  NOX GRAMS/KM                                .48               .41                .53                 .42
  FUEL CONSUMPTION BY CB L/100KM            10.95              9.59               8.28                9.13

  RUN TIME             SECONDS               508.              868.               506.                867.
  MEASURED DISTANCE    KM                    5.78              6.29               5.85                6.29
  SCF, DRY                                   .969              .969               .967                .969
       DFC, WET (DRY)                             .940 ( .916)                          .947 ( .923)
       SCF, WET (DRY)                            1.000 ( .967)                         1.000 ( .968)
       VOL (SCM)                                       206.8                                 205.8
       SAM BLR (SCM)                                    0.00                                  0.00
       KM  (MEASURED)                                  12.07                                 12.14
       FUEL CONSUMPTION L/100KM                        10.23                                  8.72

COMPOSITE RESULTS
  TEST NUMBER           822FTP                                                          3-BAG      (4-BAG)
  BAROMETER    MM HG  742.7                                 CARBON DIOXIDE       G/KM    218.9     ( 215.6)
  HUMIDITY     G/KG    15.0                                 FUEL CONSUMPTION     L/100KM  9.63     (  9.50)
  TEMPERATURE  DEG C   23.9                                 HYDROCARBONS (THC)   G/KM      .18     (   .19)
                                                            CARBON MONOXIDE      G/KM     2.05     (  2.15)
                                                            OXIDES OF NITROGEN   G/KM      .46     (   .46)


                                   HFET   VEHICLE EMISSIONS RESULTS
                                            PROJECT 05-5830-011

  TEST NO.   822FET   RUN   1               VEHICLE NO.82                          TEST WEIGHT  1134. KG( 2500. LBS)
  VEHICLE MODEL   81 FORD ESCORT            DATE    7/14/81                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
  ENGINE 1.6 L( 98. CID) L-4                BAG CART NO.  1                        GASOLINE  EM-479-F
  TRANSMISSION M4                           DYNO NO.      3                        ODOMETER  8151. KM( 5065. MILES)
                                            CVS NO.   2

  BAROMETER 742.95 MM HG(29.25 IN HG)       DRY BULB TEMP. 22.2 DEG C(72.0 DEG F)
  RELATIVE HUMIDITY  69. PCT                ABS. HUMIDITY 11.9 GM/KG               NOX HUMIDITY CORRECTION FACTOR  1.04
0 BAG RESULTS
    TEST CYCLE                                 HFET

    BLOWER DIF P MM. H2O(IN. H2O)           787.4 (31.0)
    BLOWER INLET P MM. H2O(IN. H2O)         779.8 (30.7)
    BLOWER INLET TEMP. DEG. C(DEG. F)        42.2 (108.0)
    BLOWER REVOLUTIONS                         61253.
    TOT FLOW STD. CU. METRES(SCF)           114.6 ( 4045.)
    HC  SAMPLE METER/RANGE/PPM              15.9/ 2/  16.
    HC  BCKGRD METER/RANGE/PPM               5.6/ 2/   6.
    CO  SAMPLE METER/RANGE/PPM              44.7/13/  42.
    CO  BCKGRD METER/RANGE/PPM               1.1/13/   1.
    CO2 SAMPLE METER/RANGE/PCT              65.9/ 3/ 1.18
    CO2 BCKGRD METER/RANGE/PCT               3.2/ 3/  .05
    NOX SAMPLE METER/RANGE/PPM              40.6/ 2/  41.
    NOX BCKGRD METER/RANGE/PPM                .3/ 2/   0.
    DILUTION FACTOR                            11.29
    HC  CONCENTRATION PPM                      10.
    CO  CONCENTRATION PPM                      39.
    CO2 CONCENTRATION PCT                      1.14
    NOX CONCENTRATION PPM                      40.3
    HC  MASS GRAMS                              .69
    CO  MASS GRAMS                             5.21
    CO2 MASS GRAMS                           2383.5
    NOX MASS GRAMS                             9.18
    RUN TIME               SECONDS             766.
         DFC, WET (DRY)                     .911 ( .891)
         SCF, WET (DRY)                    1.000 ( .967)
         VOL (SCM)                            114.6
         SAM BLR (SCM)                         0.00
         KM  (MEASURED)                       16.68

    TEST NUMBER,                              822FET
    BARONETER,             MM HG              743.0
    HUMIDITY,              G/KG                11.9
    TEMPERATURE,           DEG C               22.2
     CARBON DIOXIDE,        G/KM              142.9
    FUEL CONSUMPTION,      L/100KM             6.21

    HYDROCARBONS,          G/KM                 .04
    CARBON MONOXIDE,       G/KM                 .31
    OXIDES OF NITROGEN,    G/KM                 .55
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TABLE D-6. TEST NO. 823 EMISSIONS RESULTS

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                                    FTP    VEHICLE EMISSIONS RESULTS
                                             PROJECT 05-5830-011

TEST NO.   823FTP   RUN   1                  VEHICLE NO.82                       TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT               DATE     7/15/81                    ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                   BAG CART NO. 1 / CVS NO.  2         GASOLINE  EM-479-F
TRANSMISSION M4                              DYNO NO.      3                     ODOMETER  8167. KM( 5075. MILES)

BAROMETER 741.93 MM HG(29.21 IN HG)          DRY BULB TEMP. 22.8 DEG C(73.0 DEG F)
RELATIVE HUMIDITY  58. PCT                   ABS. HUMIDITY 10.2 GM/KG            NOX HUMIDITY CORRECTION FACTOR   .98
BAG RESULTS
   BAG NUMBER                                      1                  2                  3                  4
   DESCRIPTION                               COLD TRANSIENT       STABILIZED       HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)       787.4 (31.0)       784.9 (30.9)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)            774.7 (30.5)       774.7 (30.5)       777.2 (30.6)       777.2 (30.6)
   BLOWER INLET TEMP. DEG. C(DEG. F)           42.2 (108.0)       42.2 (108.0)       42.2 (108.0)       42.2 (108.0)
   BLOWER REVOLUTIONS                            40431.             69480.             40439.             69389.
   TOT FLOW STD. CU. METRES(SCF)              75.5 ( 2668.)      129.8 ( 4584.)     75.5 ( 2668.)      129.6 ( 4577.)
   HC  SAMPLE METER/RANGE/PPM                 78.8/ 2/  79.      13.7/ 2/  14.      35.7/ 2/  36.      13.8/ 2/  14.
   HC  BCKGRD METER/RANGE/PPM                 10.4/ 2/  10.       8.9/ 2/   9.       8.1/ 2/   8.       7.4/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                 97.9/11/ 515.      16.0/13/  15.      62.0/12/ 137.      38.8/13/  36.
   CO  BCKGRD METER/RANGE/PPM                  2.5/11/   7.       6.8/13/   6.       2.6/12/   5.       4.3/13/   4.
   CO2 SAMPLE METER/RANGE/PCT                 56.1/ 3/  .99      38.6/ 3/  .65      49.2/ 3/  .85      37.5/ 3/  .63
   CO2 BCKGRD METER/RANGE/PCT                  2.9/ 3/  .04       3.4/ 3/  .05       3.4/ 3/  .05       3.3/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                 17.7/ 2/  18.      10.1/ 2/  10.      18.3/ 2/  18.      10.1/ 2/  10.
   NOX BCKGRD METER/RANGE/PPM                   .7/ 2/   1.        .7/ 2/   1.        .5/ 2/   1.        .6/ 2/   1.
   DILUTION FACTOR                               12.84              20.47              15.43              21.06
   HC  CONCENTRATION PPM                         69.                 5.                28.                 7.
   CO  CONCENTRATION PPM                        489.                 8.               128.                31.
   CO2 CONCENTRATION PCT                         .94                .60                .80                .58
   NOX CONCENTRATION PPM                        17.1                9.4               17.8                9.5
   HC  MASS GRAMS                               3.01                .39               1.23                .50
   CO  MASS GRAMS                              42.98               1.26              11.23               4.73
   CO2 MASS GRAMS                             1307.1             1431.4             1110.7             1384.3
   NOX MASS GRAMS                               2.43               2.31               2.54               2.33

   HC  GRAMS/KM                                  .52                .06                .21                .08
   CO  GRAMS/KM                                 7.40                .20               1.91                .74
   CO2 GRAMS/KM                                225.1              224.4              189.3              215.8
   NOX GRAMS/KM                                  .42                .36                .43                .36
   FUEL CONSUMPTION BY CB L/100KM              10.17               9.60               8.24               9.27

   RUN TIME              SECONDS                505.               868.               505.               867.
   MEASURED DISTANCE     KM                     5.81               6.38               5.87               6.42
   SCF, DRY                                     .972               .975               .974               .976
         DFC, WET (DRY)                                 .940 ( .923)                          .946 ( .929)
         SCF, WET (DRY)                                1.000 ( .974)                         1.000 ( .975)
         VOL (SCM)                                             205.4                                 205.2
         SAM BLR (SCM)                                          0.00                                  0.00
         KM  (MEASURED)                                        12.19                                 12.28
         FUEL CONSUMPTION L/100KM                               9.87                                  8.78

COMPOSITE RESULTS                                                                                    3-BAG      (4-BAG)
   TEST NUMBER          823FTP                                   CARBON DIOXIDE       G/KM           214.9      ( 212.4)
   BAROMETER     MM HG  741.9                                    FUEL CONSUMPTION     L/100KM         9.47      (  9.38)
   HUMIDITY      G/KG    10.2                                    HYDROCARBONS (THC)   G/KM             .21      (   .21)
   TEMPERATURE   DEG C   22.8                                    CARBON MONOXIDE      G/KM            2.14      (  2.30)
                                                                 OXIDES OF NITROGEN   G/KM             .39      (   .39)
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                                      HFET   VEHICLE EMISSIONS RESULTS
                                               PROJECT 05-5830-011

  TEST NO.   823FET   RUN   1                 VEHICLE NO.82                      TEST WEIGHT  1134. KG( 2500. LBS)
  VEHICLE MODEL   81 FORD ESCORT              DATE     7/15/81                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
  ENGINE 1.6 L( 98. CID) L-4                  BAG CART NO.  1                    GASOLINE  EM-479-F
  TRANSMISSION M4                             DYNO NO.      3                    ODOMETER  8196. KM( 5093. MILES)
                                              CVS NO.   2

  BAROMETER 741.68 MM HG(29.20 IN HG)         DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
  RELATIVE HUMIDITY  49. PCT                  ABS. HUMIDITY 10.0 GM/KG           NOX HUMIDITY CORRECTION FACTOR   .98
0 BAG RESULTS
    TEST CYCLE                                   HFET

    BLOWER DIF P MM. H2O(IN. H2O)             787.4 (31.0)
    BLOWER INLET P MM. H2O(IN. H2O)           774.7 (30.5)
    BLOWER INLET TEMP. DEG. C(DEG. F)          42.8 (109.0)
    BLOWER REVOLUTIONS                           61308.
    TOT FLOW STD. CU. METRES(SCF)             114.4 ( 4039.)
    HC  SAMPLE METER/RANGE/PPM                18.5/ 2/  19.
    HC  BCKGRD METER/RANGE/PPM                 7.0/ 2/   7.
    CO  SAMPLE METER/RANGE/PPM                90.0/13/  91.
    CO  BCKGRD METER/RANGE/PPM                 2.5/13/   2.
    CO2 SAMPLE METER/RANGE/PCT                63.9/ 3/ 1.14
    CO2 BCKGRD METER/RANGE/PCT                 2.9/ 3/  .04
    NOX SAMPLE METER/RANGE/PPM                24.9/ 2/  25.
    NOX BCKGRD METER/RANGE/PPM                  .7/ 2/   1.
    DILUTION FACTOR                              11.64
    HC  CONCENTRATION PPM                        12.
    CO  CONCENTRATION PPM                        85.
    CO2 CONCENTRATION PCT                        1.10
    NOX CONCENTRATION PPM                        24.3
    HC  MASS GRAMS                                .80
    CO  MASS GRAMS                              11.33
    CO2 MASS GRAMS                             2304.5
    NOX MASS GRAMS                               5.18
    RUN TIME                  SECONDS            766.
         DFC, WET (DRY)                       .914 ( .900)
         SCF, WET (DRY)                      1.000 ( .974)
         VOL (SCM)                               114.4
         SAM BLR (SCM)                            0.00
         KM  (MEASURED)                          16.31

    TEST NUMBER,                                823FET
    BARONETER,              MM HG                741.7
    HUMIDITY,               G/KG                  10.0
    TEMPERATURE,            DEG C                 25.0
     CARBON DIOXIDE,         G/KM                141.3
    FUEL CONSUMPTION,       L/100KM               6.18

    HYDROCARBONS,           G/KM                   .05
    CARBON MONOXIDE,        G/KM                   .69
    OXIDES OF NITROGEN,     G/KM                   .32
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TABLE D-7.. TEST NO. 831 EMISSIONS RESULTS

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                                     FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                              PROJECT 05-5830-011

TEST NO.  831FTP    RUN   1              VEHICLE NO.83                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT           DATE    11/16/81                           ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4               BAG CART NO. 1 / CVS NO.  2                GASOLINE  EM-464-F
TRANSMISSION A4                          DYNO NO.       3                           ODOMETER  9665. KM( 6006. MILES)

BAROMETER 741.17 MM HG(29.18 IN HG)      DRY BULB TEMP. 23.3 DEG C(74.0 DEG F)
RELATIVE HUMIDITY  58. PCT               ABS. HUMIDITY 10.7 GM/KG                   NOX HUMIDITY CORRECTION FACTOR  1.00
BAG RESULTS
   BAG NUMBER                                    1                  2                   3                  4
   DESCRIPTION                            COLD TRANSIENT       STABILIZED         HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)          784.9 (30.9)       787.4 (31.0)        774.7 (30.5)       784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)        784.9 (30.9)       787.4 (31.0)        774.7 (30.5)       784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)       43.3 (110.0)       43.3 (110.0)        42.8 (109.0)       42.8 (109.0)
   BLOWER REVOLUTIONS                        40467.             69550.              40363.             69618.
   TOT FLOW STD. CU. METRES(SCF)           75.5 ( 2666.)     129.7 ( 4581.)       75.5 ( 2666.)     130.0 ( 4591.)
   HC  SAMPLE METER/RANGE/PPM             45.3/ 2/  45.      13.5/ 2/  14.       21.7/ 2/  22.      12.8/ 2/  13.
   HC  BCKGRD METER/RANGE/PPM              9.9/ 2/  10.       9.0/ 2/   9.        7.9/ 2/   8.       9.8/ 2/  10.
   CO  SAMPLE METER/RANGE/PPM             67.7/11/ 281.      78.6/12/ 185.       80.1/11/ 363.      54.5/12/ 117.
   CO  BCKGRD METER/RANGE/PPM               .2/11/   1.        .5/12/   1.         .5/11/   1.        .4/12/   1.
   CO2 SAMPLE METER/RANGE/PCT             53.1/ 3/  .93      34.1/ 3/  .57       45.9/ 3/  .79      33.4/ 3/  .56
   CO2 BCKGRD METER/RANGE/PCT              2.9/ 3/  .04       2.9/ 3/  .04        3.1/ 3/  .05       2.8/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM             20.8/ 2/  21.       3.4/ 2/   3.        9.3/ 2/   9.       3.2/ 2/   3.
   NOX BCKGRD METER/RANGE/PPM               .5/ 2/   1.        .4/ 2/   0.         .3/ 2/   0.        .4/ 2/   0.
   DILUTION FACTOR                            12.08              19.68               14.03              20.34
   HC  CONCENTRATION PPM                      36.                 9.                 14.                 3.
   CO  CONCENTRATION PPM                     267.               177.                346.               112.
   CO2 CONCENTRATION PCT                      .89                .53                 .74                .52
   NOX CONCENTRATION PPM                     20.3                3.0                 9.0                2.8
   HC  MASS GRAMS                            3.64                .86                1.44                .60
   CO  MASS GRAMS                           23.47              26.77               30.44              17.01
   CO2 MASS GRAMS                          1225.6             1252.3              1029.2             1228.2
   NOX MASS GRAMS                            2.94                .75                1.30                .70

   HC  GRAMS/KM                               .63                .14                 .25                .10
   CO  GRAMS/KM                              4.06               4.26                5.31               2.77
   CO2 GRAMS/KM                             212.2              199.5               179.4              199.7
   NOX GRAMS/KM                               .51                .12                 .23                .11
   FUEL CONSUMPTION BY CB L/100KM           20.18              18.98               17.29              18.78

   RUN TIME               SECONDS            504.               868.                504.               870.
   MEASURED DISTANCE      KM                 5.78               6.28                5.74               6.15
   SCF, DRY                                  .963      .967      .970                .965      .968     .970
      DFC, WET (DRY)                               .937( .920)                             .943( .925)
      TOT VOL (SCM) / SAM BLR (SCM)               205.2/  0.00                            205.5/  0.00
      KM  (MEASURED)                                 12.05                                   11.89
      FUEL CONSUMPTION L/100KM                       19.55                                   18.06

COMPOSITE RESULTS                                                                                3-BAG      (4-BAG)
   TEST NUMBER           83-FTP                                  CARBON DIOXIDE       G/KM       196.6     ( 196.7)
   BAROMETER     MM HG   741.2                                   FUEL CONSUMPTION     L/100KM    18.76     ( 18.70)
   HUMIDITY      G/KG     10.7                                   HYDROCARBONS (THC)   G/KM         .27     (   .26)
   TEMPERATURE   DEG C    23.3                                   CARBON MONOXIDE      G/KM        4.51     (  4.07)
                                                                 OXIDES OF NITROGEN   G/KM         .23     (   .23)
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                                     HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                              PROJECT 05-5830-011

TEST NO.   831FET   RUN   1              VEHICLE NO.83                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT           DATE    11/16/81                           ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4               BAG CART NO.  1                            GASOLINE  EM-464-F
TRANSMISSION A4                          DYNO NO.      3                            ODOMETER  9690. KM( 6021. MILES)
                                         CVS NO.   2

BAROMETER 741.43 MM HG(29.19 IN HG)      DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  50. PCT               ABS. HUMIDITY 10.9 GM/KG                   NOX HUMIDITY CORRECTION FACTOR  1.01
BAG RESULTS
   TEST CYCLE                                  HFET

   BLOWER DIF P MM. H2O(IN. H2O)          787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)        787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)       42.8 (109.0)
   BLOWER REVOLUTIONS                        61263.
   TOT FLOW STD. CU. METRES(SCF)          116.2 ( 4103.)
   HC  SAMPLE METER/RANGE/PPM             14.4/ 2/  14.
   HC  BCKGRD METER/RANGE/PPM              8.4/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM             59.9/13/  57.
   CO  BCKGRD METER/RANGE/PPM               .9/13/   1.
   CO2 SAMPLE METER/RANGE/PCT             62.4/ 3/ 1.11
   CO2 BCKGRD METER/RANGE/PCT              3.3/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM             13.8/ 2/  14.
   NOX BCKGRD METER/RANGE/PPM               .4/ 2/   0.
   DILUTION FACTOR                           10.36
   HC  CONCENTRATION PPM                      7.
   CO  CONCENTRATION PPM                     54.
   CO2 CONCENTRATION PCT                     1.07
   NOX CONCENTRATION PPM                     13.4
   HC  MASS GRAMS                            1.05
   CO  MASS GRAMS                            7.28
   CO2 MASS GRAMS                          2266.0
   NOX MASS GRAMS                            3.01
   RUN TIME               SECONDS            765.
         DFC, WET (DRY)                    .903 ( .889)
         SCF, WET (DRY)                   1.000 ( .961)
         VOL (SCM)                          116.2
         SAM BLR (SCM)                       0.00
         KM  (MEASURED)                     16.28

   TEST NUMBER,                              831FET
   BARONETER,           MM HG                741.4
   HUMIDITY,            G/KG                  10.9
   TEMPERATURE,         DEG C                 26.1
   CARBON DIOXIDE,      G/KM                 139.2
   FUEL CONSUMPTION,    L/100KM              12.87

   HYDROCARBONS,        G/KM                   .06
   CARBON MONOXIDE,     G/KM                   .45
   OXIDES OF NITROGEN,  G/KM                   .18
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TABLE D-8. TEST NO. 832 EMISSIONS RESULTS

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                                  FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                          PROJECT 05-5830-011

TEST NO.   832FTP   RUN   1                VEHICLE NO.83                          TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT             DATE   11/18/81                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                 BAG CART NO. 1 / CVS NO.  2            GASOLINE  EM-464-F
TRANSMISSION A4                            DYNO NO.      3                        ODOMETER  9729. KM( 6045. MILES)

BAROMETER 737.87 MM HG(29.05 IN HG)        DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  60. PCT                 ABS. HUMIDITY 12.8 GM/KG               NOX HUMIDITY CORRECTION FACTOR  1.07
BAG RESULTS
   BAG NUMBER                                    1                2                3                4
   DESCRIPTION                           COLD TRANSIENT      STABILIZED     HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)         787.4 (31.0)     784.9 (30.9)     787.4 (31.0)     784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)       787.4 (31.0)     784.9 (30.9)     787.4 (31.0)     784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)      43.3 (110.0)     42.2 (108.0)     42.8 (109.0)     42.2 (108.0)
   BLOWER REVOLUTIONS                       40413.           69534.           40391.           69456.
   TOT FLOW STD. CU. METRES(SCF)          75.0 ( 2647.)   129.3 ( 4565.)    75.0 ( 2648.)   129.1 ( 4560.)
   HC  SAMPLE METER/RANGE/PPM            51.3/ 2/  51.    15.6/ 2/  16.    22.3/ 2/  22.    14.3/ 2/  14.
   HC  BCKGRD METER/RANGE/PPM            13.7/ 2/  14.    12.7/ 2/  13.    11.1/ 2/  11.    10.8/ 2/  11.
   CO  SAMPLE METER/RANGE/PPM            75.0/11/ 327.    60.0/12/ 132.    63.2/11/ 254.    62.5/12/ 138.
   CO  BCKGRD METER/RANGE/PPM             1.3/11/   4.     1.6/12/   3.      .9/11/   3.     1.2/12/   2.
   CO2 SAMPLE METER/RANGE/PCT            55.7/ 3/  .98    35.0/ 3/  .59    47.3/ 3/  .82    34.2/ 3/  .57
   CO2 BCKGRD METER/RANGE/PCT             2.9/ 3/  .04     2.7/ 3/  .04     2.9/ 3/  .04     2.7/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM            20.6/ 2/  21.     3.8/ 2/   4.    11.3/ 2/  11.     3.9/ 2/   4.
   NOX BCKGRD METER/RANGE/PPM              .6/ 2/   1.      .6/ 2/   1.      .7/ 2/   1.      .8/ 2/   1.
   DILUTION FACTOR                          11.42            19.30            13.76            19.76
   HC  CONCENTRATION PPM                    39.               4.              12.               4.
   CO  CONCENTRATION PPM                   308.             124.             241.             131.
   CO2 CONCENTRATION PCT                    .94              .55              .77              .53
   NOX CONCENTRATION PPM                   20.1              3.2             10.7              3.1
   HC  MASS GRAMS                           3.87              .61             1.20              .70
   CO  MASS GRAMS                          26.87            18.65            21.01            19.71
   CO2 MASS GRAMS                        1286.8           1293.8           1063.0           1257.7
   NOX MASS GRAMS                           3.08              .86             1.64              .83

   HC  GRAMS/KM                              .67              .10              .21              .11
   CO  GRAMS/KM                             4.65             2.98             3.62             3.15
   CO2 GRAMS/KM                           222.8            206.7            183.4            201.2
   NOX GRAMS/KM                              .53              .14              .28              .13
   FUEL CONSUMPTION BY CB L/100KM          21.25            19.45            17.41            18.97

   RUN TIME             SECONDS           504.             868.             504.             868.
   MEASURED DISTANCE    KM                 5.77             6.26             5.80             6.25
   SCF, DRY                                 .961     .966     .969             .964     .967     .969
        DFC, WET (DRY)                            .935( .917)                        .941( .923)
        TOT VOL (SCM) / SAM BLR (SCM)            204.3/  0.00                       204.1/  0.00
        KM  (MEASURED)                              12.03                              12.05
        FUEL CONSUMPTION L/100KM                    20.31                              18.22

COMPOSITE RESULTS                                                                          3-BAG       (4-BAG)
   TEST NUMBER          832FTP                                  CARBON DIOXIDE      G/KM      203.6       ( 202.0)
   BAROMETER    MM HG   737.9                                   FUEL CONSUMPTION    L/100KM   19.26       ( 19.12)
   HUMIDITY     G/KG     12.8                                   HYDROCARBONS (THC)  G/KM        .25       (   .25)
   TEMPERATURE  DEG C    25.6                                   CARBON MONOXIDE     G/KM       3.50       (  3.55)
                                                                OXIDES OF NITROGEN  G/KM        .26       (   .26)
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                                  HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                          PROJECT 05-5830-011

TEST NO.   832FET   RUN   1                VEHICLE NO.83                          TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT             DATE   11/18/81                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                 BAG CART NO.  1                        GASOLINE  EM-464-F
TRANSMISSION A4                            DYNO NO.      3                        ODOMETER  9754. KM( 6061. MILES)
                                           CVS NO.   2

BAROMETER 737.62 MM HG(29.04 IN HG)        DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  54. PCT                 ABS. HUMIDITY 11.8 GM/KG               NOX HUMIDITY CORRECTION FACTOR  1.04
BAG RESULTS
   TEST CYCLE                                 HFET

   BLOWER DIF P MM. H2O(IN. H2O)           787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)         787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)        42.2 (108.0)
   BLOWER REVOLUTIONS                         61247.
   TOT FLOW STD. CU. METRES(SCF)           115.6 ( 4081.)
   HC  SAMPLE METER/RANGE/PPM              17.4/ 2/  17.
   HC  BCKGRD METER/RANGE/PPM              12.9/ 2/  13.
   CO  SAMPLE METER/RANGE/PPM              38.7/13/  36.
   CO  BCKGRD METER/RANGE/PPM               2.4/13/   2.
   CO2 SAMPLE METER/RANGE/PCT              66.6/ 3/ 1.20
   CO2 BCKGRD METER/RANGE/PCT               3.1/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM              17.1/ 2/  17.
   NOX BCKGRD METER/RANGE/PPM                .7/ 2/   1.
   DILUTION FACTOR                              9.65
   HC  CONCENTRATION PPM                        6.
   CO  CONCENTRATION PPM                       32.
   CO2 CONCENTRATION PCT                        1.15
   NOX CONCENTRATION PPM                       16.5
   HC  MASS GRAMS                                .90
   CO  MASS GRAMS                               4.32
   CO2 MASS GRAMS                            2439.3
   NOX MASS GRAMS                               3.77
   RUN TIME                 SECONDS            765.
        DFC, WET (DRY)                      .896 ( .881)
        SCF, WET (DRY)                     1.000 ( .959)
        VOL (SCM)                              115.6
        SAM BLR (SCM)                           0.00
        KM  (MEASURED)                         16.46

   TEST NUMBER,                               832FET
   BAROMETER,               MM HG              737.6
   HUMIDITY,                G/KG                11.8
   TEMPERATURE,             DEG C               26.1
   CARBON DIOXIDE,          G/KM               148.2
   FUEL CONSUMPTION,        L/100KM             13.67

   HYDROCARBONS,            G/KM                 .09
   CARBON MONOXIDE,         G/KM                 .26
   OXIDES OF NITROGEN,      G/KM                 .23
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TABLE D-9. TEST NO. 833 EMISSIONS RESULTS

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                                        FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-5830-011

TEST NO.   833FTP   RUN   1                     VEHICLE NO.83                      TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                  DATE    11/19/81                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                      BAG CART NO. 1 / CVS NO.  2        GASOLINE  EM-464-F
TRANSMISSION A4                                 DYNO NO.     3                     ODOMETER  9771. KM( 6072. MILES)

BAROMETER 739.90 MM HG(29.13 IN HG)             DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  50. PCT                      ABS. HUMIDITY 10.5 GM/KG           NOX HUMIDITY CORRECTION FACTOR   .99
BAG RESULTS
   BAG NUMBER                                         1                  2                   3                   4
   DESCRIPTION                                 COLD TRANSIENT       STABILIZED        HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)                784.9 (30.9)       784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)              784.9 (30.9)       784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)             43.3 (110.0)       42.8 (109.0)       42.8 (109.0)       42.8 (109.0)
   BLOWER REVOLUTIONS                              40474.             69543.             40434.             69481.
   TOT FLOW STD. CU. METRES(SCF)                75.4 ( 2662.)      129.7 ( 4578.)      75.4 ( 2662.)      129.5 ( 4574.)
   HC  SAMPLE METER/RANGE/PPM                   55.7/ 2/  56.      12.4/ 2/  12.      19.6/ 2/  20.      10.4/ 2/  10.
   HC  BCKGRD METER/RANGE/PPM                   11.5/ 2/  12.       9.5/ 2/  10.       7.8/ 2/   8.       7.3/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                   70.6/11/ 299.      60.6/12/ 133.      81.4/12/ 195.      62.2/12/ 137.
   CO  BCKGRD METER/RANGE/PPM                     .8/11/   2.        .8/12/   1.        .5/12/   1.        .3/12/   1.
   CO2 SAMPLE METER/RANGE/PCT                   52.4/ 3/  .91      33.3/ 3/  .55      44.8/ 3/  .77      33.1/ 3/  .55
   CO2 BCKGRD METER/RANGE/PCT                    2.5/ 3/  .04       2.6/ 3/  .04       2.7/ 3/  .04       3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                   27.2/ 2/  27.       3.1/ 2/   3.       9.5/ 2/  10.       3.1/ 2/   3.
   NOX BCKGRD METER/RANGE/PPM                     .7/ 2/   1.        .5/ 2/   1.        .5/ 2/   1.        .7/ 2/   1.
   DILUTION FACTOR                                 12.22              20.35              14.69              20.47
   HC  CONCENTRATION PPM                           45.                 3.                12.                 3.
   CO  CONCENTRATION PPM                          283.               127.               185.               132.
   CO2 CONCENTRATION PCT                           .88                .52                .73                .51
   NOX CONCENTRATION PPM                          26.6                2.6                9.0                2.4
   HC  MASS GRAMS                                  4.53               .58               1.24                .60
   CO  MASS GRAMS                                 24.88              19.23              16.24              19.98
   CO2 MASS GRAMS                                1212.6             1227.5             1006.6             1203.9
   NOX MASS GRAMS                                  3.80               .65               1.29                .60

   HC  GRAMS/KM                                     .78                .09                .21                .10
   CO  GRAMS/KM                                    4.28               3.06               2.80               3.19
   CO2 GRAMS/KM                                   208.7              195.4              173.3              192.4
   NOX GRAMS/KM                                     .65                .10                .22                .10
   FUEL CONSUMPTION BY CB L/100KM                 19.91              18.42              16.37              18.17

   RUN TIME             SECONDS                   505.               868.               505.               868.
   MEASURED DISTANCE    KM                        5.81               6.28               5.81               6.26
   SCF, DRY                                       .966      .970      .973              .969      .971      .973
        DFC, WET (DRY)                                  .939( .924)                          .944( .929)
        TOT VOL (SCM) / SAM BLR (SCM)                  205.1/  0.00                         204.9/  0.00
        KM  (MEASURED)                                    12.09                                12.06
        FUEL CONSUMPTION L/100KM                          19.13                                17.30

COMPOSITE RESULTS                                                                            3-BAG       (4-BAG)
   TEST NUMBER          833FTP                              CARBON DIOXIDE       G/KM        192.1      ( 191.2)
   BAROMETER    MM HG   739.9                               FUEL CONSUMPTION     L/100KM     18.17      ( 18.09)
   HUMIDITY     G/KG     10.5                               HYDROCARBONS (THC)   G/KM          .27      (    .27)
   TEMPERATURE  DEG C    25.6                               CARBON MONOXIDE      G/KM         3.24      (   3.28)
                                                            OXIDES OF NITROGEN   G/KM          .25      (    .25)
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                                        HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-5830-011

TEST NO.   833FET   RUN   1                     VEHICLE NO.83                      TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                  DATE    11/19/81                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                      BAG CART NO.  1                    GASOLINE  EM-464-F
TRANSMISSION A4                                 DYNO NO.      3                    ODOMETER  9796. KM( 6087. MILES)
                                                CVS NO.   2

BAROMETER 741.43 MM HG(29.19 IN HG)             DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  40. PCT                      ABS. HUMIDITY  8.4 GM/KG           NOX HUMIDITY CORRECTION FACTOR   .93
BAG RESULTS
   TEST CYCLE                                      HFET

   BLOWER DIF P MM. H2O(IN. H2O)                784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)              784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)             42.2 (108.0)
   BLOWER REVOLUTIONS                              61223.
   TOT FLOW STD. CU. METRES(SCF)                116.3 ( 4107.)
   HC  SAMPLE METER/RANGE/PPM                   12.0/ 2/  12.
   HC  BCKGRD METER/RANGE/PPM                    7.2/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                   38.6/13/  36.
   CO  BCKGRD METER/RANGE/PPM                     .3/13/   0.
   CO2 SAMPLE METER/RANGE/PCT                   61.9/ 3/ 1.10
   CO2 BCKGRD METER/RANGE/PCT                    3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                   14.5/ 2/  15.
   NOX BCKGRD METER/RANGE/PPM                     .4/ 2/   0.
   DILUTION FACTOR                                 10.48
   HC  CONCENTRATION PPM                            5.
   CO  CONCENTRATION PPM                           34.
   CO2 CONCENTRATION PCT                           1.06
   NOX CONCENTRATION PPM                           14.1
   HC  MASS GRAMS                                   .85
   CO  MASS GRAMS                                  4.60
   CO2 MASS GRAMS                                2255.6
   NOX MASS GRAMS                                  2.92
   RUN TIME                SECONDS                765.
        DFC, WET (DRY)                          .905 ( .893)
        SCF, WET (DRY)                         1.000 ( .965)
        VOL (SCM)                                 116.3
        SAM BLR (SCM)                              0.00
        KM  (MEASURED)                            16.41

   TEST NUMBER,                                   833FET
   BAROMETER,            MM HG                    741.4
   HUMIDITY,             G/KG                       8.4
   TEMPERATURE,          DEG C                     25.6
   CARBON DIOXIDE,       G/KM                     137.4
   FUEL CONSUMPTION,     L/100KM                  12.68

   HYDROCARBONS,         G/KM                       .05
   CARBON MONOXIDE,      G/KM                       .28
   OXIDES OF NITROGEN,   G/KM                       .18
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TABLE D-10. TEST NO. 841 EMISSIONS RESULTS

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                                          FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                   PROJECT 05-5830-011

TEST NO.   841FTP   RUN   1                 VEHICLE NO.                            TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                DATE   11/ 9/81                        ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                  BAG CART NO. 1 / CVS NO.  2            GASOLINE  EM-464-F
TRANSMISSION A3                             DYNO NO.      3                        ODOMETER  2305. KM( 1432. MILES)

BAROMETER 750.32 MM HG(29.54 IN HG)         DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  30. PCT                  ABS. HUMIDITY  5.9 GM/KG               NOX HUMIDITY CORRECTION FACTOR   .86
BAG RESULTS
   BAG NUMBER                                      1                  2                  3                  4
   DESCRIPTION                              COLD TRANSIENT       STABILIZED        HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)            784.9 (30.9)       787.4 (31.0)       782.3 (30.8)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)          784.9 (30.9)       787.4 (31.0)       782.3 (30.8)       787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)         43.3 (110.0)       41.1 (106.0)       42.2 (108.0)       40.6 (105.0)
   BLOWER REVOLUTIONS                          40469.             69577.             40460.             69458.
   TOT FLOW STD. CU. METRES(SCF)             76.6 ( 2704.)     132.1 ( 4665.)      76.7 ( 2709.)     132.0 ( 4662.)
   HC  SAMPLE METER/RANGE/PPM               74.3/ 2/  74.       7.9/ 2/   8.       7.9/ 2/   8.       6.9/ 2/   7.
   HC  BCKGRD METER/RANGE/PPM                8.7/ 2/   9.       6.9/ 2/   7.       6.2/ 2/   6.       6.1/ 2/   6.
   CO  SAMPLE METER/RANGE/PPM               72.3/12/ 166.       6.3/13/   6.      14.5/13/  13.       4.2/13/   4.
   CO  BCKGRD METER/RANGE/PPM                1.8/12/   3.       2.4/13/   2.       1.0/13/   1.        .8/13/   1.
   CO2 SAMPLE METER/RANGE/PCT               49.6/ 3/  .86      31.2/ 3/  .52      44.6/ 3/  .76      31.2/ 3/  .52
   CO2 BCKGRD METER/RANGE/PCT                3.0/ 3/  .05       2.5/ 3/  .04       2.3/ 3/  .04       2.4/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               26.9/ 2/  27.      10.5/ 2/  11.      19.5/ 2/  20.       9.7/ 2/  10.
   NOX BCKGRD METER/RANGE/PPM                 .7/ 2/   1.        .6/ 2/   1.        .4/ 2/   0.        .4/ 2/   0.
   DILUTION FACTOR                             13.12              22.34              15.12              22.35
   HC  CONCENTRATION PPM                        66.                 1.                 2.                 1.
   CO  CONCENTRATION PPM                       157.                 3.                12.                 3.
   CO2 CONCENTRATION PCT                        .82                .48                .73                .48
   NOX CONCENTRATION PPM                       26.3                9.9               19.1                9.3
   HC  MASS GRAMS                              6.76                .23                .22                .19
   CO  MASS GRAMS                             13.99                .54               1.06                .46
   CO2 MASS GRAMS                            1145.4             1162.5             1027.2             1165.3
   NOX MASS GRAMS                              3.32               2.17               2.42               2.03

   HC  GRAMS/KM                                1.16                .04                .04                .03
   CO  GRAMS/KM                                2.41                .09                .18                .07
   CO2 GRAMS/KM                               197.3              186.2              178.0              187.5
   NOX GRAMS/KM                                 .57                .35                .42                .33
   FUEL CONSUMPTION BY CB L/100KM             18.63              17.13              16.39              17.26

   RUN TIME             SECONDS                504.               868.               505.               868.
   MEASURED DISTANCE    KM                     5.81               6.25               5.77               6.21
   SCF, DRY                                    .973       .978    .980               .975       .978    .980
         DFC, WET (DRY)                               .944( .935)                           .947( .938)
         TOT VOL (SCM) / SAM BLR (SCM)               208.7/  0.00                          208.8/  0.00
         KM  (MEASURED)                                 12.05                                 11.99
         FUEL CONSUMPTION L/100KM                       17.85                                 16.84

COMPOSITE RESULTS
   TEST NUMBER          841FTP                                                                3-BAG       (4-BAG)
   BARONETER    MM HG   750.3                             CARBON DIOXIDE       G/KM          186.2      ( 186.6)
   HUMIDITY     G/KG      5.9                             FUEL CONSUMPTION     L/100KM       17.24      ( 17.28)
   TEMPERATURE  DEG C    25.0                             HYDROCARBONS (THC)   G/KM            .27      (   .27)
                                                          CARBON MONOXIDE      G/KM            .59      (   .59)
                                                          OXIDES OF NITROGEN   G/KM            .41      (   .41)
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                                          HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                   PROJECT 05-5830-011

TEST NO.   841FET   RUN   1                 VEHICLE NO.
VEHICLE MODEL   81 VW RABBIT                DATE   11/ 9/81                        TEST WEIGHT  1134. KG( 2500. LBS)
ENGINE 1.6 L( 97. CID) L-4                  BAG CART NO.  1                        ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
TRANSMISSION A3                             DYNO NO.      3                        GASOLINE  EM-464-F
                                            CVS NO.   2                            ODOMETER  2329. KM( 1447. MILES)

BAROMETER 750.82 MM HG(29.56 IN HG)         DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  33. PCT                  ABS. HUMIDITY  6.5 GM/KG               NOX HUMIDITY CORRECTION FACTOR   .88
BAG RESULTS
   TEST CYCLE                                  HFET

   BLOWER DIF P MM. H2O(IN. H2O)            800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)          800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.8 (109.0)
   BLOWER REVOLUTIONS                          61205.
   TOT FLOW STD. CU. METRES(SCF)            115.7 ( 4086.)
   HC  SAMPLE METER/RANGE/PPM                6.1/ 2/   6.
   HC  BCKGRD METER/RANGE/PPM                6.3/ 2/   6.
   CO  SAMPLE METER/RANGE/PPM               24.4/13/  22.
   CO  BCKGRD METER/RANGE/PPM                 .3/13/   0.
   CO2 SAMPLE METER/RANGE/PCT               66.9/ 3/ 1.20
   CO2 BCKGRD METER/RANGE/PCT                2.5/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               10.6/ 2/  11.
   NOX BCKGRD METER/RANGE/PPM                 .1/ 2/   0.
   DILUTION FACTOR                              9.62
   HC  CONCENTRATION PPM                         0.
   CO  CONCENTRATION PPM                        21.
   CO2 CONCENTRATION PCT                        1.17
   NOX CONCENTRATION PPM                        10.5
   HC  MASS GRAMS                                .07
   CO  MASS GRAMS                               2.83
   CO2 MASS GRAMS                             2472.4
   NOX MASS GRAMS                               2.04
   RUN TIME             SECONDS                 764.
         DFC, WET (DRY)                      .896 ( .887)
         SCF, WET (DRY)                     1.000 ( .965)
         VOL (SCM)                             115.7
         SAM BLR (SCM)                          0.00
         KM  (MEASURED)                        16.41

   TEST NUMBER,                                841FET
   BAROMETER,           MM HG                   750.8
   HUMIDITY,            G/KG                      6.5
   TEMPERATURE,         DEG C                    25.0
   CARBON DIOXIDE,      G/KM                    150.6
   FUEL CONSUMPTION,    L/100KM                 13.87

   HYDROCARBONS,        G/KM                      .00
   CARBON MONOXIDE,     G/KM                      .17
   OXIDES OF NITROGEN,  G/KM                      .12
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TABLE D-11. TEST NO. 842 EMISSIONS RESULTS

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                                          FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                  PROJECT 05-5830-011

TEST NO.   842FTP   RUN   1                   VEHICLE NO.                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                  DATE    11/10/81                         ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                    BAG CART NO. 1 / CVS NO.  2              GASOLINE  EM-464-F
TRANSMISSION A3                               DYNO NO.      3                          ODOMETER  2345. KM( 1457. MILES)

BAROMETER 751.84 MM HG(29.60 IN HG)           DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  34. PCT                    ABS. HUMIDITY  6.4 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .87
BAG RESULTS
   BAG NUMBER                                        1                   2                    3                   4
   DESCRIPTION                               COLD TRANSIENT         STABILIZED         HOT TRANSIENT          STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)        800.1 (31.5)         787.4 (31.0)        787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)            787.4 (31.0)        800.1 (31.5)         787.4 (31.0)        787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)           43.3 (110.0)        41.7 (107.0)         42.2 (108.0)        41.7 (107.0)
   BLOWER REVOLUTIONS                            40550.              69555.               40449.              69429.
   TOT FLOW STD. CU. METRES(SCF)               76.3 ( 2694.)      131.0 ( 4627.)        76.3 ( 2693.)      131.0 ( 4626.)
   HC  SAMPLE METER/RANGE/PPM                 80.3/ 2/  80.       15.5/ 2/  16.        11.3/ 2/  11.        9.4/ 2/   9.
   HC  BCKGRD METER/RANGE/PPM                 17.7/ 2/  18.       14.3/ 2/  14.         9.0/ 2/   9.        8.4/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM                 72.6/12/ 167.       17.4/13/  16.        25.2/13/  23.       11.7/13/  11.
   CO  BCKGRD METER/RANGE/PPM                  9.6/12/  18.       14.8/13/  13.        11.9/13/  11.        8.5/13/   8.
   CO2 SAMPLE METER/RANGE/PCT                 49.0/ 3/  .85       30.8/ 3/  .51        44.1/ 3/  .75       30.8/ 3/  .51
   CO2 BCKGRD METER/RANGE/PCT                  3.0/ 3/  .05        3.0/ 3/  .05         2.9/ 3/  .04        3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                 24.7/ 2/  25.       10.4/ 2/  10.        19.3/ 2/  19.       10.1/ 2/  10.
   NOX BCKGRD METER/RANGE/PPM                   .4/ 2/   0.         .5/ 2/   1.          .8/ 2/   1.         .7/ 2/   1.
   DILUTION FACTOR                               13.28               22.57                15.28               22.62
   HC  CONCENTRATION PPM                          64.                  2.                   3.                  1.
   CO  CONCENTRATION PPM                         144.                  3.                  12.                  3.
   CO2 CONCENTRATION PCT                          .81                 .47                  .71                 .47
   NOX CONCENTRATION PPM                         24.3                 9.9                 18.6                 9.4
   HC  MASS GRAMS                                6.50                 .32                  .29                 .24
   CO  MASS GRAMS                               12.80                 .41                 1.09                 .47
   CO2 MASS GRAMS                              1125.2              1118.0                995.5              1117.9
   NOX MASS GRAMS                                3.11                2.18                 2.37                2.07

   HC  GRAMS/KM                                  1.11                 .05                  .05                 .04
   CO  GRAMS/KM                                  2.19                 .07                  .19                 .07
   CO2 GRAMS/KM                                 192.7               178.8                172.0               178.0
   NOX GRAMS/KM                                   .53                 .35                  .41                 .33
   FUEL CONSUMPTION BY CB L/100KM               18.17               16.45                15.85               16.38

   RUN TIME            SECONDS                   505.                868.                 505.                868.
   MEASURED DISTANCE   KM                        5.84                6.25                 5.79                6.28
   SCF, DRY                                      .972       .976      .979                 .974       .977     .979
        DFC, WET (DRY)                                 .944( .934)                               .948( .938)
        TOT VOL (SCM) / SAM BLR (SCM)                 207.3/  0.00                              207.3/  0.00
        KM  (MEASURED)                                    12.09                                     12.07
        FUEL CONSUMPTION L/100KM                          17.28                                     16.13

COMPOSITE RESULTS                                                                                      3-BAG       (4-BAG)
    TEST NUMBER          842FTP                                       CARBON DIOXIDE       G/KM        179.8       ( 179.6)
    BAROMETER     MM HG  751.8                                        FUEL CONSUMPTION     L/100KM     16.64       ( 16.62)
    HUMIDITY      G/KG     6.4                                        HYDROCARBONS (THC)   G/KM          .27       (   .27)
    TEMPERATURE   DEG C   23.9                                        CARBON MONOXIDE      G/KM          .54       (   .54)
                                                                      OXIDES OF NITROGEN   G/KM          .40       (   .40)
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                                          HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                  PROJECT 05-5830-011

TEST NO.   842FET   RUN   1                   VEHICLE NO.                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                  DATE    11/10/81                         ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                    BAG CART NO.  1                          GASOLINE  EM-464-F
TRANSMISSION A3                               DYNO NO.      3                          ODOMETER  2369. KM( 1472. MILES)
                                              CVS NO.   2

BAROMETER 752.05 MM HG(29.61 IN HG)           DRY BULB TEMP. 26.7 DEG C(80.0 DEG F)
RELATIVE HUMIDITY  24. PCT                    ABS. HUMIDITY  5.2 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .85
BAG RESULTS
   TEST CYCLE                                     HFET

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)            787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)           42.8 (109.0)
   BLOWER REVOLUTIONS                            61227.
   TOT FLOW STD. CU. METRES(SCF)              115.3 ( 4073.)
   HC  SAMPLE METER/RANGE/PPM                  8.0/ 2/   8.
   HC  BCKGRD METER/RANGE/PPM                  7.5/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM                 23.5/13/  21.
   CO  BCKGRD METER/RANGE/PPM                  4.1/13/   4.
   CO2 SAMPLE METER/RANGE/PCT                 66.9/ 3/ 1.20
   CO2 BCKGRD METER/RANGE/FCT                  2.7/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                 11.8/ 2/  12.
   NOX BCKGRD METER/RANGE/PPM                   .8/ 2/   1.
   DILUTION FACTOR                                9.62
   HC  CONCENTRATION PPM                            1.
   CO  CONCENTRATION PPM                           17.
   CO2 CONCENTRATION PCT                          1.16
   NOX CONCENTRATION PPM                          11.1
   HC  MASS GRAMS                                  .20
   CO  MASS GRAMS                                 2.31
   CO2 MASS GRAMS                               2458.7
   NOX MASS GRAMS                                 2.07
   RUN TIME              SECONDS                  766.
        DFC, WET (DRY)                        .896 ( .989)
        SCF, WET (DRY)                       1.000 ( .968)
        VOL (SCM)                                115.3
        SAM BLR (SCM)                             0.00
        KM  (MEASURED)                           16.48

    TEST NUMBER,                                842FET
    BAROMETER,           MM HG                   752.1
    HUMIDITY,            G/KG                      5.2
    TEMPERATURE,         DEG C                    26.7
    CARBON DIOXIDE,      G/KM                    149.2
    FUEL CONSUMPTION,    L/100KM                 13.74

    HYDROCARBONS,        G/KM                      .01
    CARBON MONOXIDE,     G/KM                      .14
    OXIDES OF NITROGEN,  G/KM                      .13
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TABLE D-12. TEST NO. 843 EMISSIONS RESULTS

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                                     FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                              PROJECT 05-5830-011

TEST NO.   843FTP   RUN   1                        VEHICLE NO.                              TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                       DATE    11/12/81                         ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                         BAG CART NO. 1 / CVS NO.  2              GASOLINE  EM-464-F
TRANSMISSION A3                                    DYNO NO.      3                          ODOMETER  2397. KM( 1489. MILES)

BAROMETER 745.74 MM HG(29.36 IN HG)                DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  48. PCT                         ABS. HUMIDITY  9.0 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .95
BAG RESULTS
  BAG NUMBER                                           1                   2                   3                   4
  DESCRIPTION                                    COLD TRANSIENT       STABILIZED         HOT TRANSIENT        STABILIZED

  BLOWER DIF P MM. H2O(IN. H2O)                  734.9 (30.9)        787.4 (31.0)        787.4 (31.0)        787.4 (31.0)
  BLOWER INLET P MM. H2O(IN. H2O)                784.9 (30.9)        787.4 (31.0)        784.9 (30.9)        784.9 (30.9)
  BLOWER INLET TEMP. DEG. C(DEG. F)               43.3 (110.0)        42.8 (109.0)        42.8 (109.0)        42.8 (109.0)
  BLOWER REVOLUTIONS                               40519.              69562.              40550.              69361.
  TOT FLOW STD. CU. METRES(SCF)                   76.2 ( 2689.)      130.8 ( 4619.)       76.3 ( 2693.)      130.5 ( 4607.)
  HC  SAMPLE METER/RANGE/PPM                     60.6/ 2/  61.       13.4/ 2/  13.       11.6/ 2/  12.       10.2/ 2/  10.
  HC  BCKGRD METER/RANGE/PPM                     14.4/ 2/  14.       13.5/ 2/  14.       11.2/ 2/  11.       10.5/ 2/  11.
  CO  SAMPLE METER/RANGE/PPM                     70.8/12/ 162.       16.5/13/  15.       24.8/13/  23.       10.1/13/   9.
  CO  BCKGRD METER/RANGE/PPM                      9.1/12/  17.       13.7/13/  12.        8.5/13/   8.        7.4/13/   7.
  CO2 SAMPLE METER/RANGE/PCT                     50.9/ 3/  .88       32.3/ 3/  .54       46.4/ 3/  .80       32.6/ 3/  .54
  CO2 BCKGRD METER/RANGE/PCT                      3.7/ 3/  .06        3.5/ 3/  .05        3.3/ 3/  .05        3.4/ 3/  .05
  NOX SAMPLE METER/RANGE/PPM                     27.2/ 2/  27.       10.9/ 2/  11.       19.8/ 2/  20.        9.8/ 2/  10.
  NOX BCKGRD METER/RANGE/PPM                      1.4/ 2/   1.         .8/ 2/   1.         .7/ 2/   1.         .9/ 2/   1.
  DILUTION FACTOR                                   12.78               21.46               14.45               21.28
  HC  CONCENTRATION PPM                             47.                  1.                  1.                  0.
  CO  CONCENTRATION PPM                            139.                  3.                 15.                  3.
  CO2 CONCENTRATION PCT                             .83                 .49                 .75                 .49
  NOX CONCENTRATION PPM                             25.9                10.1                19.1                 8.9
  HC  MASS GRAMS                                    4.80                .09                 .12                 .03
  CO  MASS GRAMS                                   12.33                .43                1.31                 .39
  CO2 MASS GRAMS                                  1160.3              1163.2              1048.9              1176.6
  NOX MASS GRAMS                                    3.57                2.40                2.65                2.11

  HC  GRAMS/KM                                      .82                 .01                 .02                 .01
  CO  GRAMS/KM                                     2.11                 .07                 .22                 .06
  CO2 GRAMS/KM                                    198.9               183.3               178.5               183.8
  NOX GRAMS/KM                                      .61                 .38                 .45                 .33
  FUEL CONSUMPTION BY CB L/100KM                  18.70               16.87               16.44               16.91

  RUN TIME              SECONDS                   505.                868.                506.                866.
  MEASURED DISTANCE     KM                        5.83                6.34                5.88                6.40
  SCF, DRY                                        .967                .974                .969                .974
       DFC, WET (DRY)                                       .971                                .972
       TOT VOL (SCM) / SAM BLR (SCM)                    .942( .927)                         .945( .930)
       KM  (MEASURED)                                  207.0/  0.00                        206.7/  0.00
       FUEL CONSUMPTION L/100KM                            12.18                               12.28
                                                           17.75                               16.68
COMPOSITE RESULTS
  TEST NUMBER              843FTP                                                            3-BAG      (4-BAG)
  BAROMETER      MM HG  745.7                   CARBON DIOXIDE         G/KM                  185.2      ( 185.3)
  HUMIDITY       G/KG     9.0                   FUEL CONSUMPTION       L/100KM               17.13      ( 17.14)
  TEMPERATURE    DEG C   23.9                   HYDROCARBONS (THC)     G/KM                    .18      (   .18)
                                                CARBON MONOXIDE        G/KM                    .53      (   .53)
                                                OXIDES OF NITROGEN     G/KM                    .45      (   .43)
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                                    HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                              PROJECT 05-5830-011

TEST NO.   843FET   RUN   1                        VEHICLE NO.
VEHICLE MODEL   81 VW RABBIT                       DATE    11/12/81                         TEST WEIGHT  1134. KG( 2500. LBS)
ENGINE 1.6 L( 97. CID) L-4                         BAG CART NO.  1                          ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
TRANSMISSION A3                                    DYNO NO.      3                          GASOLINE  EM-464-F
                                                   CVS NO.   2                              ODOMETER  2421. KM( 1505. MILES)

BAROMETER 745.74 MM HG(29.36 IN HG)                DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  46. PCT                         ABS. HUMIDITY  9.2 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .95
BAG RESULTS
  TEST CYCLE                                         HFET

  BLOWER DIF P MM. H2O(IN. H2O)                  800.1 (31.5)
  BLOWER INLET P MM. H2O(IN. H2O)                800.1 (31.5)
  BLOWER INLET TEMP. DEG. C(DEG. F)               42.8 (109.0)
  BLOWER REVOLUTIONS                               61259.
  TOT FLOW STD. CU. METRES(SCF)                  114.1 ( 4029.)
  HC  SAMPLE METER/RANGE/PPM                     10.2/ 2/  10.
  HC  BCKGRD METER/RANGE/PPM                     10.4/ 2/  10.
  CO  SAMPLE METER/RANGE/PPM                     21.2/13/  19.
  CO  BCKGRD METER/RANGE/PPM                      5.2/13/   5.
  CO2 SAMPLE METER/RANGE/PCT                     67.4/ 3/ 1.21
  CO2 BCKGRD METER/RANGE/PCT                      3.8/ 3/  .06
  NOX SAMPLE METER/RANGE/PPM                     11.6/ 2/  12.
  NOX BCKGRD METER/RANGE/PPM                      1.0/ 2/   1.
  DILUTION FACTOR                                    9.54
  HC  CONCENTRATION PPM                               1.
  CO  CONCENTRATION PPM                              14.
  CO2 CONCENTRATION PCT                             1.16
  NOX CONCENTRATION PPM                             10.7
  HC  MASS GRAMS                                     .14
  CO  MASS GRAMS                                    1.89
  CO2 MASS GRAMS                                  2422.0
  NOX MASS GRAMS                                    2.23
  RUN TIME              SECONDS                     765.
       DFC, WET (DRY)                            .895 ( .882)
       SCF, WET (DRY)                           1.000 ( .961)
       VOL (SCM)                                   114.1
       SAM BLR (SCM)                                0.00
       KM  (MEASURED)                              16.46

  TEST NUMBER,                                    843FET
  BAROMETER,              MM HG                    745.7
  HUMIDITY,               G/KG                       9.2
  TEMPERATURE,            DEG C                     25.0
  CARBON DIOXIDE,         G/KM                     147.1
  FUEL CONSUMPTION,       L/100KM                  13.54

  HYDROCARBONS,           G/KM                       .01
  CARBON MONOXIDE,        G/KM                       .11
  OXIDES OF NITROGEN,     G/KM                       .14
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TABLE D-13. TEST NO. 851 EMISSIONS RESULTS

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                                   FTP   - VEHICLE EMISSIONS RESULTS -
                                              PROJECT 05-5830-011

TEST NO.   851FTP   RUN   1                   VEHICLE NO.85                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                  DATE   11/20/81                       ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.7 L(105. CID) L-4                    BAG CART NO. 1 / CVS NO.  2           GASOLINE  EM-338-F
TRANSMISSION A3                               DYNO NO.      3                       ODOMETER 12793. KM( 7949. MILES)

BAROMETER 751.59 MM HG(29.59 IN HG)           DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  27. PCT                    ABS. HUMIDITY  5.7 GM/KG              NOX HUMIDITY CORRECTION FACTOR   .86
BAG RESULTS
   BAG NUMBER                                      1                  2                  3                  4
   DESCRIPTION                              COLD TRANSIENT       STABILIZED       HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)            787.4 (31.0)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)          787.4 (31.0)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.8 (109.0)       41.7 (107.0)       42.2 (108.0)       41.7 (107.0)
   BLOWER REVOLUTIONS                          40453.             69561.             40425.             69476.
   TOT FLOW STD. CU. METRES(SCF)             76.7 ( 2709.)      132.2 ( 4668.)      76.7 ( 2710.)     132.0 ( 4662.)
   HC  SAMPLE METER/RANGE/PPM               38.6/ 2/  39.      10.4/ 2/  10.      16.9/ 2/  17.       8.4/ 2/   8.
   HC  BCKGRD METER/RANGE/PPM               10.6/ 2/  11.       9.4/ 2/   9.       8.2/ 2/   8.       7.5/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM               77.9/12/ 183.       5.2/13/   5.      10.4/13/   9.       3.7/13/   3.
   CO  BCKGRD METER/RANGE/PPM                2.7/12/   5.       4.2/13/   4.       2.7/13/   2.       2.3/13/   2.
   CO2 SAMPLE METER/RANGE/PCT               58.5/ 3/ 1.03      37.4/ 3/  .63      53.1/ 3/  .93      37.0/ 3/  .62
   CO2 BCKGRD METER/RANGE/PCT                2.8/ 3/  .04       2.9/ 3/  .04       2.9/ 3/  .04       3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                9.7/ 2/  10.       2.8/ 2/   3.       3.7/ 2/   4.       3.1/ 2/   3.
   NOX BCKGRD METER/RANGE/PPM                 .3/ 2/   0.        .2/ 2/   0.        .2/ 2/   0.        .2/ 2/   0.
   DILUTION FACTOR                              12.70              21.23              14.41              21.49
   HC  CONCENTRATION PPM                        29.                1.                 9.                 1.
   CO  CONCENTRATION PPM                       173.                1.                 7.                 1.
   CO2 CONCENTRATION PCT                        .99                .59                .89                .58
   NOX CONCENTRATION PPM                        9.4                2.6                3.5                2.9
   HC  MASS GRAMS                               1.28               .11                .41                .10
   CO  MASS GRAMS                              15.43               .16                .62                .20
   CO2 MASS GRAMS                             1396.0             1421.6             1244.8             1398.5
   NOX MASS GRAMS                               1.19               .57                .44                .63

   HC  GRAMS/KM                                  .22               .02                .07                .02
   CO  GRAMS/KM                                 2.66               .02                .11                .03
   CO2 GRAMS/KM                                240.8              227.1              215.3              223.6
   NOX GRAMS/KM                                  .20               .09                .08                .10
   FUEL CONSUMPTION BY CB L/100KM              10.49               9.70               9.21               9.55

   RUN TIME                SECONDS             504.               868.               505.               868.
   MEASURED DISTANCE       KM                  5.80               6.26               5.78               6.25
   SCF, DRY                                    .982       .984    .985               .983       .984    .985
        DFC, WET (DRY)                               .941( .933)                           .945( .937)
        TOT VOL (SCM) / SAM BLR (SCM)               208.9/  0.00                          208.8/  0.00
        KM  (MEASURED)                                 12.06                                 12.04
        FUEL CONSUMPTION L/100KM                       10.08                                  9.38

COMPOSITE RESULTS                                                                               3-BAG      (4-BAG)
    TEST NUMBER          851FTP                                 CARBON DIOXIDE       G/KM      226.7      ( 225.7)
    BAROMETER     MM HG  751.6                                  FUEL CONSUMPTION     L/100KM     9.73      (  9.68)
    HUMIDITY      G/KG     5.7                                  HYDROCARBONS (THC)   G/KM        .07      (   .07)
    TEMPERATURE   DEG C   25.6                                  CARBON MONOXIDE      G/KM        .59      (   .59)
                                                                OXIDES OF NITROGEN   G/KM        .11      (   .11)
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                                   HFET  - VEHICLE EMISSIONS RESULTS -
                                              PROJECT 05-5830-011

TEST NO.   851FET   RUN   1                   VEHICLE NO.85                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                  DATE   11/20/81                       ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.7 L(105. CID) L-4                    BAG CART NO.  1                       GASOLINE  EM-338-F
TRANSMISSION A3                               DYNO NO.      3                       ODOMETER 12817. KM( 7964. MILES)
                                              CVS NO.   2

BAROMETER 751.59 MM HG(29.59 IN HG)           DRY BULB TEMP. 26.7 DEG C(80.0 DEG F)
RELATIVE HUMIDITY  26. PCT                    ABS. HUMIDITY  5.8 GM/KG              NOX HUMIDITY CORRECTION FACTOR   .86
BAG RESULTS
   TEST CYCLE                                    HFET

   BLOWER DIF P MM. H2O(IN. H2O)            789.9 (31.1)
   BLOWER INLET P MM. H2O(IN. H2O)          789.9 (31.1)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.2 (108.0)
   BLOWER REVOLUTIONS                          61178.
   TOT FLOW STD. CU. METRES(SCF)            117.9 ( 4163.)
   HC  SAMPLE METER/RANGE/PPM               22.4/ 2/  22.
   HC  BCKGRD METER/RANGE/PPM                6.9/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM               96.2/13/  98.
   CO  BCKGRD METER/RANGE/PPM                2.2/13/   2.
   CO2 SAMPLE METER/RANGE/PCT               75.9/ 3/ 1.38
   CO2 BCKGRD METER/RANGE/PCT                2.8/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                3.9/ 2/   4.
   NOX BCKGRD METER/RANGE/PPM                 .4/ 2/   0.
   DILUTION FACTOR                              9.59
   HC  CONCENTRATION PPM                        16.
   CO  CONCENTRATION PPM                        92.
   CO2 CONCENTRATION PCT                        1.35
   NOX CONCENTRATION PPM                        3.5
   HC  MASS GRAMS                               1.10
   CO  MASS GRAMS                              12.70
   CO2 MASS GRAMS                             2906.9
   NOX MASS GRAMS                                .69
   RUN TIME                SECONDS             765.
        DFC, WET (DRY)                       .896 ( .888)
        SCF, WET (DRY)                      1.000 ( .979)
        VOL (SCM)                              117.9
        SAM BLR (SCM)                           0.00
        KM  (MEASURED)                         16.37

   TEST NUMBER,                                851FET
   BAROMETER,            MM HG                 751.6
   HUMIDITY,             G/KG                    5.8
   TEMPERATURE,          DEG C                  26.7
   CARBON DIOXIDE,       G/KM                  177.5
   FUEL CONSUMPTION,     L/100KM                7.64

   HYDROCARBONS,         G/KM                    .07
   CARBON MONOXIDE,      G/KM                    .78
   OXIDES OF NITROGEN,   G/KM                    .04
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TABLE D-14. TEST NO. 852 EMISSIONS RESULTS

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                                  FTP   - VEHICLE EMISSIONS RESULTS -
                                          PROJECT 05-5830-011

TEST NO.   852FTP   RUN   1                     VEHICLE NO.85                      TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                    DATE    11/23/81                   ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.7 L(105. CID) L-4                      BAG CART NO. 1 / CVS NO.  2        GASOLINE  EM-338-F
TRANSMISSION A3                                 DYNO NO.      3                    ODOMETER 12845. KM( 7982. MILES)

BAROMETER 739.65 MM HG(29.12 IN HG)             DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  57. PCT                      ABS. HUMIDITY 12.0 GM/KG           NOX HUMIDITY CORRECTION FACTOR  1.04
BAG RESULTS
   BAG NUMBER                                        1                  2                   3                   4
   DESCRIPTION                                COLD TRANSIENT        STABILIZED        HOT TRANSIENT         STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)        787.4 (31.0)       787.4 (31.0)        784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)            787.4 (31.0)        787.4 (31.0)       787.4 (31.0)        784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)           42.2 (108.0)        41.7 (107.0)       41.1 (106.0)        42.2 (108.0)
   BLCWER REVOLUTIONS                            40465.              69556.             40447.              69418.
   TOT FLOW STD. CU. METRES(SCF)               75.7 ( 2672.)      130.2 ( 4598.)      75.8 ( 2676.)      129.9 ( 4585.)
   HC  SAMPLE METER/RANGE/PPM                 37.9/ 2/  38.        9.4/ 2/   9.       17.9/ 2/  18.        9.1/ 2/   9.
   HC  BCKGRD METER/RANGE/PPM                  9.7/ 2/  10.        9.4/ 2/   9.        8.9/ 2/   9.        9.2/ 2/   9.
   CO  SAMPLE METER/RANGE/PPM                 86.7/12/ 210.        4.1/13/   4.       16.2/13/  15.        4.7/13/   4.
   CO  BCKGRD METER/RANGE/PPM                   .5/12/   1.        1.1/13/   1.        1.6/13/   1.        1.3/13/   1.
   CO2 SAMPLE METER/RANGE/PCT                 61.4/ 3/ 1.09       39.3/ 3/  .66       55.0/ 3/  .96       38.9/ 3/  .66
   CO2 BCKGRD METER/RANGE/PCT                  2.9/ 3/  .04        2.8/ 3/  .04        3.0/ 3/  .05        3.1/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                  8.6/ 2/   9.        1.7/ 2/   2.        3.1/ 2/   3.         .9/ 2/   1.
   NOX BCKGRD METER/RANGE/PPM                   .5/ 2/   1.         .5/ 2/   1.         .5/ 2/   1.         .6/ 2/   1.
   DILUTION FACTOR                                12.02               20.12              13.85               20.34
   HC  CONCENTRATION PPM                          29.                  0.                10.                  0.
   CO  CONCENTRATION PPM                         201.                  3.                13.                  3.
   CO2 CONCENTRATION PCT                          1.05                 .62                .92                 .61
   NOX CONCENTRATION PPM                          8.1                 1.2                2.6                  .3
   HC  MASS GRAMS                                 1.27                 .04                .42                 .03
   CO  MASS GRAMS                                17.73                 .40               1.13                 .46
   CO2 MASS GRAMS                               1455.0              1487.6             1278.9              1455.5
   NOX MASS GRAMS                                 1.23                 .32                .40                 .09

   HC  GRAMS/KM                                    .22                 .01                .07                 .00
   CO  GRAMS/KM                                   3.07                 .06                .20                 .07
   CO2 GRAMS/KM                                  252.1               239.7              220.1               231.6
   NOX GRAMS/KM                                    .21                 .05                .07                 .01
   FUEL CONSUMPTION BY CB L/100KM                11.00               10.24               9.42                9.89

   RUN TIME              SECONDS                 505.                868.               505.                867.
   MEASURED DISTANCE     KM                      5.77                6.21               5.81                6.29
   SCF, DRY                                      .972       .974     .976               .973       .975     .976
        DFC, WET (DRY)                               .938( .921)                            .942( .925)
        TOT VOL (SCM) / SAM BLR (SCM)               205.9/  0.00                           205.6/  0.00
        KM  (MEASURED)                                 11.98                                  12.09
        FUEL CONSUMPTION L/100KM                       10.60                                   9.66

COMPOSITE RESULTS                                                                          3-BAG       (4-BAG)
   TEST NUMBER          852FTP                              CARBON DIOXIDE       G/KM      236.9      ( 234.5)
   BAROMETER    MM HG  739.6                                FUEL CONSUMPTION     L/100KM   10.17      ( 10.07)
   HUMIDITY     G/KG    12.0                                HYDROCARBONS (THC)   G/KM        .07      (    .07)
   TEMPERATURE  DEG C   25.6                                CARBON MONOXIDE      G/KM        .72      (    .73)
                                                            OXIDES OF NITROGEN   G/KM        .09      (    .08)
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                                  HFET  - VEHICLE EMISSIONS RESULTS -
                                          PROJECT 05-5830-011

  TEST NO.  852FET   RUN   1                      VEHICLE NO.85                    TEST WEIGHT  1134. KG( 2500. LBS)
  VEHICLE MODEL   81 VW RABBIT                    DATE    11/23/81                 ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
  ENGINE 1.7 L(105. CID) L-4                      BAG CART NO.  1                  GASOLINE  EM-338-F
  TRANSMISSION A3                                 DYNO NO.      3                  ODOMETER 12870. KM( 7997. MILES)
                                                  CVS NO.   2

  BAROMETER 739.14 MM HG(29.10 IN HG)             DRY BULB TEMP. 27.8 DEG C(82.0 DEG F)
  RELATIVE HUMIDITY  49. PCT                      ABS. HUMIDITY 11.8 GM/KG         NOX HUMIDITY CORRECTION FACTOR  1.04
  BAG RESULTS
     TEST CYCLE                                      HFET

     BLOWER DIF P MM. H2O(IN. H2O)                800.1 (31.5)
     BLOWER INLET P MM. H2O(IN. H2O)              800.1 (31.5)
     BLOWER INLET TEMP. DEG. C(DEG. F)             42.8 (109.0)
     BLOWER REVOLUTIONS                              61199.
     TOT FLOW STD. CU. METRES(SCF)                116.0 ( 4095.)
     HC  SAMPLE METER/RANGE/PPM                   24.1/ 2/  24.
     HC  BCKGRD METER/RANGE/PPM                    9.1/ 2/   9.
     CO  SAMPLE METER/RANGE/PPM                   48.5/12/ 102.
     CO  BCKGRD METER/RANGE/PPM                     .5/12/   1.
     CO2 SAMPLE METER/RANGE/PCT                   79.6/ 3/ 1.46
     CO2 BCKGRD METER/RANGE/PCT                    2.8/ 3/  .04
     NOX SAMPLE METER/RANGE/PPM                    4.0/ 2/   4.
     NOX BCKGRD METER/RANGE/PPM                     .5/ 2/   1.
     DILUTION FACTOR                                  9.09
     HC  CONCENTRATION PPM                            16.
     CO  CONCENTRATION PPM                            97.
     CO2 CONCENTRATION PCT                           1.42
     NOX CONCENTRATION PPM                            3.6
     HC  MASS GRAMS                                  1.07
     CO  MASS GRAMS                                 13.09
     CO2 MASS GRAMS                                3022.1
     NOX MASS GRAMS                                   .82
     RUN TIME                 SECONDS                765.
          DFC, WET (DRY)                          .890 ( .876)
          SCF, WET (DRY)                         1.000 ( .971)
          VOL (SCM)                                 116.0
          SAM BLR (SCM)                              0.00
          KM  (MEASURED)                            16.40

     TEST NUMBER,                                  851FET
     BAROMETER,             MM HG                   739.1
     HUMIDITY,              G/KG                     11.8
     TEMPERATURE,           DEG C                    27.8
     CARBON DIOXIDE,        G/KM                    184.2
     FUEL CONSUMPTION,      L/100KM                  7.93

     HYDROCARBONS,          G/KM                      .07
     CARBON MONOXIDE,       G/KM                      .80
     OXIDES OF NITROGEN,    G/KM                      .05
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TABLE D-15. TEST NO. 853 EMISSIONS RESULTS

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                                     FTP   - VEHICLE EMISSIONS RESULTS -
                                              PROJECT 05-5830-011

TEST NO.   853FTP   RUN   1                        VEHICLE NO.85                            TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                       DATE   11/24/81                          ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.7 L(105. CID) L-4                         BAG CART NO. 1 / CVS NO.  2              GASOLINE  EM-338-F
TRANSMISSION A3                                    DYNO NO.      3                          ODOMETER 12887. KM( 8008. MILES)

BAROMETER 743.46 MM HG(29.27 IN HG)                DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  43. PCT                         ABS. HUMIDITY  9.0 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .95
BAG RESULTS
   BAG NUMBER                                              1                  2                   3                  4
   DESCRIPTION                                      COLD TRANSIENT       STABILIZED        HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)                    787.4 (31.0)       784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)                  787.4 (31.0)       784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)                 42.8 (109.0)       42.2 (108.0)       42.8 (109.0)       42.2 (108.0)
   BLOWER REVOLUTIONS                                  40477.             69577.             40398.             69501.
   TOT FLOW STD. CU. METRES(SCF)                     76.2 ( 2690.)     131.1 ( 4630.)      76.1 ( 2685.)     131.0 ( 4625.)
   HC   SAMPLE METER/RANGE/PPM                      41.6/ 2/  42.      10.6/ 2/  11.      12.4/ 2/  12.       9.4/ 2/   9.
   HC   BCKGRD METER/RANGE/PPM                      10.8/ 2/  11.      10.4/ 2/  10.       9.9/ 2/  10.       9.7/ 2/  10.
   CO   SAMPLE METER/RANGE/PPM                      89.1/12/ 218.       4.6/13/   4.      10.6/13/  10.       4.7/13/   4.
   CO   BCKGRD METER/RANGE/PPM                       1.8/12/   3.       3.0/13/   3.       2.3/13/   2.       2.1/13/   2.
   CO2  SAMPLE METER/RANGE/PCT                      59.4/ 3/ 1.05      38.0/ 3/  .64      53.2/ 3/  .93      37.4/ 3/  .63
   CO2  BCKGRD METER/RANGE/PCT                       2.9/ 3/  .04       2.9/ 3/  .04       3.0/ 3/  .05       3.4/ 3/  .05
   NOX  SAMPLE METER/RANGE/PPM                       7.7/ 2/   8.       2.6/ 2/   3.       3.7/ 2/   4.        .8/ 2/   1.
   NOX  BCKGRD METER/RANGE/PPM                        .2/ 2/   0.        .3/ 2/   0.        .3/ 2/   0.        .7/ 2/   1.
   DILUTION FACTOR                                     12.45              20.87              14.39              21.24
   HC   CONCENTRATION PPM                              32.                 1.                 3.                 0.
   CO   CONCENTRATION PPM                             208.                 1.                 7.                 2.
   CO2  CONCENTRATION PCT                              1.01               .60                .89                .58
   NOX  CONCENTRATION PPM                              7.5                2.3                3.4                 .1
   HC   MASS GRAMS                                     1.39               .05                .14                .01
   CO   MASS GRAMS                                    18.43               .23                .65                .36
   CO2  MASS GRAMS                                  1409.0             1436.7             1234.3             1390.8
   NOX  MASS GRAMS                                     1.04               .55                .47                .03

   HC   GRAMS/KM                                        .24               .01                .02                .00
   CO   GRAMS/KM                                       3.19               .04                .11                .06
   CO2  GRAMS/KM                                      244.0              230.4              213.8              222.1
   NOX  GRAMS/KM                                        .18               .09                .08                .01
   FUEL CONSUMPTION BY CB L/100KM                     10.66               9.84               9.14               9.48

   RUN TIME             SECONDS                       504.               868.               504.               868.
   MEASURED DISTANCE    KM                            5.78               6.24               5.77               6.26
   SCF, DRY                                           .976      .979      .980               .977      .979     .980
        DFC, WET (DRY)                                       .940( .927)                            .945( .932)
        TOT VOL (SCM) / SAM BLR (SCM)                        207.3/  0.00                           207.0/  0.00
        KM  (MEASURED)                                          12.01                                  12.04
        FUEL CONSUMPTION L/100KM                                10.23                                   9.32
                                                                                                    3-BAG       (4-BAG)
COMPOSITE RESULTS                                                         CARBON DIOXIDE       G/KM      228.6       ( 226.2)
   TEST NUMBER            853FTP                                          FUEL CONSUMPTION     L/100KM    9.81       (  9.71)
   BAROMETER     MM HG  743.5                                             HYDROCARBONS (THC)   G/KM        .06       (   .06)
   HUMIDITY      G/KG     9.0                                             CARBON MONOXIDE      G/KM        .71       (   .72)
   TEMPERATURE   DEG C   25.6                                             OXIDES OF NITROGEN   G/KM        .11       (   .08)
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                                     HFET  - VEHICLE EMISSIONS RESULTS -
                                              PROJECT 05-5830-011

TEST NO.   853FET   RUN   1                        VEHICLE NO.85                            TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                       DATE   11/24/81                          ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.7 L(105. CID) L-4                         BAG CART NO.  1                          GASOLINE  EM-338-F
TRANSMISSION A3                                    DYNO NO.      3                          ODOMETER 12911. KM( 8023. MILES)
                                                   CVS NO.   2

BAROMETER 743.71 MM HG(29.28 IN HG)                DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  44. PCT                         ABS. HUMIDITY  9.5 GM/KG                 NOX HUMIDITY CORRECTION FACTOR   .96
BAG RESULTS
   TEST CYCLE                                         HFET

   BLOWER DIF P MM. H2O(IN. H2O)                   800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)                 800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)                42.8 (109.0)
   BLOWER REVOLUTIONS                                  61205.
   TOT FLOW STD. CU. METRES(SCF)                   116.8 ( 4126.)
   HC   SAMPLE METER/RANGE/PPM                      21.5/ 2/  22.
   HC   BCKGRD METER/RANGE/PPM                       7.8/ 2/   8.
   CO   SAMPLE METER/RANGE/PPM                      93.5/13/  95.
   CO   BCKGRD METER/RANGE/PPM                       1.3/13/   1.
   CO2  SAMPLE METER/RANGE/PCT                      76.0/ 3/ 1.39
   CO2  BCKGRD METER/RANGE/PCT                       2.6/ 3/  .04
   NOX  SAMPLE METER/RANGE/PPM                       2.7/ 2/   3.
   NOX  BCKGRD METER/RANGE/PPM                        .7/ 2/   1.
   DILUTION FACTOR                                      9.58
   HC   CONCENTRATION PPM                              15.
   CO   CONCENTRATION PPM                              90.
   CO2  CONCENTRATION PCT                              1.35
   NOX  CONCENTRATION PPM                              2.1
   HC   MASS GRAMS                                      .98
   CO   MASS GRAMS                                    12.20
   CO2  MASS GRAMS                                   2891.0
   NOX  MASS GRAMS                                      .44
   RUN TIME                 SECONDS                   765.
        DFC, WET (DRY)                              .896 ( .883)
        SCF, WET (DRY)                             1.000 ( .973)
        VOL  (SCM)                                    116.8
        SAM BLR (SCM)                                  0.00
        KM  (MEASURED)                                16.31

   TEST NUMBER,                                      853FET
   BAROMETER,             MM HG                       743.7
   HUMIDITY,              G/KG                          9.5
   TEMPERATURE,           DEG C                        26.1
   CARBON DIOXIDE,        G/KM                        177.3
   FUEL CONSUMPTION,      L/100KM                      7.63

   HYDROCARBONS,          G/KM                          .06
   CARBON MONOXIDE,       G/KM                          .75
   OXIDES OF NITROGEN,    G/KM                          .03
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TABLE D-16. TEST NO. 861 EMISSIONS RESULTS

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                              FTP   - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                      PROJECT 05-6619-001

TEST NO.   861FTP   RUN   1                     VEHICLE NO.86                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                    DATE    12/18/81                      ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                      BAG CART NO. 1 / CVS NO.  2           GASOLINE  EM-464-F
TRANSMISSION A3                                 DYNO NO.      3                       ODOMETER  2849. KM( 1770. MILES)

BAROMETER 754.13 MM HG(29.69 IN HG)             DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  16. PCT                      ABS. HUMIDITY  3.3 GM/KG              NOX HUMIDITY CORRECTION FACTOR   .80
BAG RESULTS
   BAG NUMBER                                         1                  2                   3                  4
   DESCRIPTION                                 COLD TRANSIENT       STABILIZED        HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)               787.4 (31.0)        787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)             787.4 (31.0)        787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)            42.2 (108.0)        40.6 (105.0)       41.7 (107.0)       41.1 (106.0)
   BLOWER REVOLUTIONS                             40569.              69459.             40415.             69443.
   TOT FLOW STD. CU. METRES(SCF)               77.3 ( 2729.)       132.7 ( 4686.)     77.1 ( 2721.)      132.5 ( 4680.)
   HC  SAMPLE METER/RANGE/PPM                   9.5/ 3/  95.        15.2/ 2/  15.      21.2/ 2/  21.      14.9/ 2/  15.
   HC  BCKGRD METER/RANGE/PPM                    .7/ 3/   7.         7.1/ 2/   7.       6.8/ 2/   7.       6.5/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                  61.5/11/ 245.        68.6/13/  67.      58.9/12/ 129.      38.5/12/  79.
   CO  BCKGRD METER/RANGE/PPM                   1.4/11/   4.         6.1/13/   6.       3.8/12/   7.       4.3/12/   8.
   CO2 SAMPLE METER/RANGE/PCT                  48.7/ 3/  .84        30.4/ 3/  .50      43.5/ 3/  .74      29.2/ 3/  .48
   CO2 BCKGRD METER/RANGE/PCT                   2.7/ 3/  .04         2.4/ 3/  .04       2.8/ 3/  .04       2.0/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM                  63.3/ 2/  63.        27.5/ 2/  28.      61.8/ 2/  62.      27.0/ 2/  27.
   NOX BCKGRD METER/RANGE/PPM                    .4/ 2/   0.          .3/ 2/   0.        .4/ 2/   0.        .5/ 2/   1.
   DILUTION FACTOR                                13.23               22.67              15.28              23.60
   HC  CONCENTRATION PPM                          89.                  8.                15.                 9.
   CO  CONCENTRATION PPM                         233.                 60.               118.                69.
   CO2 CONCENTRATION PCT                          .80                 .47                .70                .45
   NOX CONCENTRATION PPM                         62.9                27.2               61.4               26.5
   HC  MASS GRAMS                                 9.11                1.49               1.52               1.53
   CO  MASS GRAMS                                20.99                9.28              10.63              10.71
   CO2 MASS GRAMS                              1137.5              1136.5              992.1             1097.3
   NOX MASS GRAMS                                 7.48                5.55               7.28               5.40

   HC  GRAMS/KM                                   1.57                .24                .26                .25
   CO  GRAMS/KM                                   3.62               1.49               1.83               1.72
   CO2 GRAMS/KM                                 196.1               182.2              171.0              175.9
   NOX GRAMS/KM                                   1.29                .89               1.25                .87
   FUEL CONSUMPTION BY CB L/100KM                18.75               16.99              16.02              16.45

   RUN TIME                  SECONDS            506.                867.               505.               868.
   MEASURED DISTANCE         KM                 5.80                6.24               5.80               6.24
   SCF, DRY                                     .978       .982     .985               .980       .983    .985
        DFC, WET (DRY)                               .944( .939)                            .949( .944)
        TOT VOL (SCM) / SAM BLR (SCM)               210.0/ 0.00                            209.6/ 0.00
        KM  (MEASURED)                                12.04                                  12.04
        FUEL CONSUMPTION L/100KM                      17.84                                  16.24

COMPOSITE RESULTS                                                                                 3-BAG      (4-BAG)
   TEST NUMBER          861FTP                                     CARBON DIOXIDE       G/KM      182.0      ( 180.1)
   BAROMETER    MM HG  754.1                                       FUEL CONSUMPTION     L/100KM   17.09      ( 16.93)
   HUMIDITY     G/KG     3.3                                       HYDROCARBONS (THC)   G/KM        .52      (   .52)
   TEMPERATURE  DEG C   25.6                                       CARBON MONOXIDE      G/KM       2.02      (  2.09)
                                                                   OXIDES OF NITROGEN   G/KM       1.07      (  1.07)
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                              HFET  - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                      PROJECT 05-6619-001

TEST NO.   861FET   RUN   1                     VEHICLE NO.86                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                    DATE    12/18/81                      ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                      BAG CART NO.  1                       GASOLINE  EM-464-F
TRANSMISSION A3                                 DYNO NO.      3                       ODOMETER  2873. KM( 1785. MILES)
                                                CVS NO.   2

BAROMETER 754.89 MM HG(29.72 IN HG)             DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  15. PCT                      ABS. HUMIDITY  3.0 GM/KG              NOX HUMIDITY CORRECTION FACTOR   .80
BAG RESULTS
   TEST CYCLE                                        HFET

   BLOWER DIF P MM. H2O(IN. H2O)                787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)              787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)             42.8 (109.0)
   BLOWER REVOLUTIONS                              61172.
   TOT FLOW STD. CU. METRES(SCF)                118.3 ( 4178.)
   HC  SAMPLE METER/RANGE/PPM                   22.7/ 2/  23.
   HC  BCKGRD METER/RANGE/PPM                    6.5/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM                   96.4/12/ 243.
   CO  BCKGRD METER/RANGE/PPM                    3.1/13/   3.
   CO2 SAMPLE METER/RANGE/PCT                   61.9/ 3/ 1.10
   CO2 BCKGRD METER/RANGE/PCT                    1.6/ 3/  .02
   NOX SAMPLE METER/RANGE/PPM                   96.1/ 2/  96.
   NOX BCKGRD METER/RANGE/PPM                     .9/ 2/   1.
   DILUTION FACTOR                                 10.28
   HC  CONCENTRATION PPM                           17.
   CO  CONCENTRATION PPM                          231.
   CO2 CONCENTRATION PCT                           1.08
   NOX CONCENTRATION PPM                          95.3
   HC  MASS GRAMS                                  2.65
   CO  MASS GRAMS                                 31.88
   CO2 MASS GRAMS                               2337.0
   NOX MASS GRAMS                                 17.19
   RUN TIME                 SECONDS              765.
        DFC, WET (DRY)                         .903 ( .898)
        SCF, WET (DRY)                        1.000 ( .973)
        VOL (SCM)                                118.3
        SAM BLR (SCM)                              0.00
        KM  (MEASURED)                            16.27

   TEST NUMBER,                                 861FET
   BAROMETER,           MM HG                    754.9
   HUMIDITY,            G/KG                       3.0
   TEMPERATURE,         DEG C                     25.0
   CARBON DIOXIDE,      G/KM                     143.7
   FUEL CONSUMPTION,    L/100KM                  13.51

   HYDROCARBONS,        G/KM                       .16
   CARBON MONOXIDE,     G/KM                      1.96
   OXIDES OF NITROGEN,  G/KM                      1.06
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TABLE D-17. TEST NO. 862 EMISSIONS RESULTS

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                                     FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-6619-001

TEST NO.   862FTP   RUN   1                     VEHICLE NO.86                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                    DATE   12/21/81                       ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                      BAG CART NO. 1 / CVS NO.  2           GASOLINE  EM-464-F
TRANSMISSION A3                                 DYNO NO.       3                      ODOMETER  2903. KM( 1804. MILES)

BAROMETER 735.08 MM HG(28.94 IN HG)             DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  56. PCT                      ABS. HUMIDITY 11.1 GM/KG              NOX HUMIDITY CORRECTION FACTOR  1.01
BAG RESULTS
   BAG NUMBER                                        1                  2                   3                   4
   DESCRIPTION                                COLD TRANSIENT       STABILIZED         HOT TRANSIENT         STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)              787.4 (31.0)        784.9 (30.9)        787.4 (31.0)        774.7 (30.5)
   BLOWER INLET P MM. H2O(IN. H2O)            787.4 (31.0)        784.9 (30.9)        787.4 (31.0)        774.7 (30.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)           42.8 (109.0)        42.2 (108.0)        42.2 (108.0)        42.2 (108.0)
   BLOWER REVOLUTIONS                            40497.              69538.              40447.              69482.
   TOT FLOW STD. CU. METRES(SCF)               74.9 ( 2646.)      128.8 ( 4549.)       74.9 ( 2645.)      128.9 ( 4552.)
   HC  SAMPLE METER/RANGE/PPM                 10.1/ 3/ 101.       18.3/ 2/  18.       24.2/ 2/  24.       17.3/ 2/  17.
   HC  BCKGRD METER/RANGE/PPM                   .9/ 3/   9.        9.9/ 2/  10.        9.2/ 2/   9.        9.0/ 2/   9.
   CO  SAMPLE METER/RANGE/PPM                 64.4/11/ 261.       81.7/13/  81.       62.5/12/ 138.       81.8/13/  81.
   CO  BCKGRD METER/RANGE/PPM                   .8/11/   2.        2.4/13/   2.        1.0/12/   2.        1.7/13/   2.
   CO2 SAMPLE METER/RANGE/PCT                 49.2/ 3/  .85       30.4/ 3/  .50       43.5/ 3/  .74       29.5/ 3/  .49
   CO2 BCKGRD METER/RANGE/PCT                  2.6/ 3/  .04        1.9/ 3/  .03        2.1/ 3/  .03        1.9/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM                 53.8/ 2/  54.       22.1/ 2/  22.       49.7/ 2/  50.       21.5/ 2/  22.
   NOX BCKGRD METER/RANGE/PPM                   .4/ 2/   0.         .6/ 2/   1.         .7/ 2/   1.         .7/ 2/   1.
   DILUTION FACTOR                                13.06               22.60               15.26               23.33
   HC  CONCENTRATION PPM                          93.                  9.                 16.                  9.
   CO  CONCENTRATION PPM                         248.                 76.                131.                 77.
   CO2 CONCENTRATION PCT                          .82                 .48                 .71                 .46
   NOX CONCENTRATION PPM                         53.4                21.5                49.0                20.8
   HC  MASS GRAMS                                 9.25                1.52                1.56                1.49
   CO  MASS GRAMS                                21.59               11.45               11.42               11.57
   CO2 MASS GRAMS                               1118.0              1120.5               978.1              1083.3
   NOX MASS GRAMS                                 7.74                5.36                7.10                5.19

   HC  GRAMS/KM                                   1.59                 .24                 .27                 .24
   CO  GRAMS/KM                                   3.71                1.84                1.98                1.87
   CO2 GRAMS/KM                                  192.3               180.3               169.2               175.5
   NOX GRAMS/KM                                   1.33                 .86                1.23                 .84
   FUEL CONSUMPTION BY CB L/100KM                18.41               16.88               15.87               16.43

   RUN TIME              SECONDS                 505.                868.                505.                868.
   MEASURED DISTANCE     KM                      5.82                6.21                5.78                6.17
   SCF, DRY                                      .965       .969      .972               .967       .970      .972
        DFC, WET (DRY)                                .944( .927)                            .949( .932)
        TOT VOL (SCM) / SAM BLR (SCM)                203.7/  0.00                           203.8/  0.00
        KM  (MEASURED)                                  12.03                                  11.96
        FUEL CONSUMPTION L/100KM                        17.62                                  16.16

COMPOSITE RESULTS                                                                                   3-BAG       (4-BAG)
   TEST NUMBER         862FTP                                         CARBON DIOXIDE       G/KM     179.7      ( 178.3)
   BAROMETER    MM HG  735.1                                          FUEL CONSUMPTION     L/100KM  16.92      ( 16.79)
   HUMIDITY     G/KG    11.1                                          HYDROCARBONS (THC)   G/KM       .53      (   .53)
   TEMPERATURE  DEG C   24.4                                          CARBON MONOXIDE      G/KM      2.27      (  2.28)
                                                                      OXIDES OF NITROGEN   G/KM      1.06      (  1.05)
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                                     HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-6619-001

TEST NO.   862FET   RUN   1                     VEHICLE NO.86                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                    DATE   12/21/81                       ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                      BAG CART NO.  1                       GASOLINE  EM-464-F
TRANSMISSION A3                                 DYNO NO.      3                       ODOMETER  2927. KM( 1819. MILES)
                                                CVS NO.   2

BAROMETER 735.08 MM HG(28.94 IN HG)             DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  50. PCT                      ABS. HUMIDITY 11.1 GM/KG              NOX HUMIDITY CORRECTION FACTOR  1.01
BAG RESULTS
   TEST CYCLE                                      HFET

   BLOWER DIF P MM. H2O(IN. H2O)                789.9 (31.1)
   BLOWER INLET P MM. H2O(IN. H2O)              789.9 (31.1)
   BLOWER INLET TEMP. DEG. C(DEG. F)             42.2 (108.0)
   BLOWER REVOLUTIONS                              61245.
   TOT FLOW STD. CU. METRES(SCF)                115.1 ( 4065.)
   HC  SAMPLE METER/RANGE/PPM                   26.1/ 2/  26.
   HC  BCKGRD METER/RANGE/PPM                    9.0/ 2/   9.
   CO  SAMPLE METER/RANGE/PPM                   65.0/11/ 265.
   CO  BCKGRD METER/RANGE/PPM                     .5/11/   1.
   CO2 SAMPLE METER/RANGE/PCT                   64.4/ 3/ 1.15
   CO2 BCKGRD METER/RANGE/PCT                    1.9/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM                   78.1/ 2/  78.
   NOX BCKGRD METER/RANGE/PPM                     .6/ 2/   1.
   DILUTION FACTOR                                  9.82
   HC  CONCENTRATION PPM                            18.
   CO  CONCENTRATION PPM                           250.
   CO2 CONCENTRATION PCT                           1.12
   NOX CONCENTRATION PPM                           77.6
   HC  MASS GRAMS                                   2.76
   CO  MASS GRAMS                                  33.48
   CO2 MASS GRAMS                                2371.0
   NOX MASS GRAMS                                  17.27
   RUN TIME              SECONDS                   765.
        DFC, WET (DRY)                          .898 ( .884)
        SCF, WET (DRY)                         1.000 ( .961)
        VOL (SCM)                                  115.1
        SAM BLR (SCM)                               0.00
        KM  (MEASURED)                             16.38

   TEST NUMBER,                                   862FET
   BAROMETER,            MM HG                     735.1
   HUMIDITY,             G/KG                       11.1
   TEMPERATURE,          DEG C                      26.1
   CARBON DIOXIDE,       G/KM                      144.8
   FUEL CONSUMPTION,     L/100KM                   13.63

   HYDROCARBONS,         G/KM                        .17
   CARBON MONOXIDE,      G/KM                       2.04
   OXIDES OF NITROGEN,   G/KM                       1.05
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TABLE D-18. TEST NO. 863 EMISSIONS RESULTS

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                                 FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                          PROJECT 05-6619-001

TEST NO.   863FTP   RUN   1                 VEHICLE NO.86                        TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                DATE   12/22/81                      ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                  BAG CART NO. 1 / CVS NO.  2          GASOLINE  EM-464-F
TRANSMISSION A3                             DYNO NO.      3                      ODOMETER  2943. KM( 1829. MILES)

BAROMETER 729.74 MM HG(28.73 IN HG)         DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  38. PCT                  ABS. HUMIDITY  8.3 GM/KG             NOX HUMIDITY CORRECTION FACTOR   .93
BAG RESULTS
   BAG NUMBER                                     1                2                  3                  4
   DESCRIPTION                              COLD TRANSIENT     STABILIZED       HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)            774.7 (30.5)      774.7 (30.5)      774.7 (30.5)       774.7 (30.5)
   BLOWER INLET P MM. H2O(IN. H2O)          774.7 (30.5)      774.7 (30.5)      774.7 (30.5)       774.7 (30.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.2 (108.0)      42.8 (109.0)      42.2 (108.0)       42.2 (108.0)
   BLOWER REVOLUTIONS                          40502.            69990.            40455.             69452.
   TOT FLOW STD. CU. METRES(SCF)             74.6 ( 2632.)    127.9 ( 4516.)     74.5 ( 2629.)     127.8 ( 4513.)
   HC   SAMPLE METER/RANGE/PPM              10.5/ 3/ 105.     21.9/ 2/  22.     30.0/ 2/  30.      19.7/ 2/  20.
   HC   BCKGRD METER/RANGE/PPM               1.2/ 3/  12.     12.9/ 2/  13.     11.9/ 2/  12.      10.8/ 2/  11.
   CO   SAMPLE METER/RANGE/PPM              72.2/11/ 309.     88.9/13/  89.     69.5/12/ 198.      90.0/13/  91.
   CO   BCKGRD METER/RANGE/PPM               4.2/11/  12.     11.2/13/  10.      3.4/12/   6.       6.2/13/   6.
   CO2 SAMPLE METER/RANGE/PCT               53.3/ 3/  .93     33.1/ 3/  .55     46.0/ 3/  .79      31.6/ 3/  .52
   CO2 BCKGRD METER/RANGE/PCT                3.3/ 3/  .05      3.7/ 3/  .06      2.9/ 3/  .04       2.9/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               62.9/ 2/  63.     27.1/ 2/  27.     59.2/ 2/  59.      29.2/ 2/  29.
   NOX BCKGRD METER/RANGE/PPM                1.1/ 2/   1.      1.0/ 2/   1.      1.0/ 2/   1.       1.0/ 2/   1.
   DILUTION FACTOR                              11.92             20.68             14.32              21.64
   HC   CONCENTRATION PPM                        94.               10.               19.                 9.
   CO   CONCENTRATION PPM                       285.               77.              146.                83.
   CO2 CONCENTRATION PCT                         .88               .50               .75                .48
   NOX CONCENTRATION PPM                        61.9              26.1              58.3               24.2
   HC   MASS GRAMS                              9.33              1.70              1.91               1.60
   CO   MASS GRAMS                             24.75             11.49             12.68              12.31
   CO2 MASS GRAMS                             1207.6            1164.3            1021.4             1127.9
   NOX MASS GRAMS                               8.18              5.93              7.69               5.50

   HC   GRAMS/KM                                1.60               .27               .33                .26
   CO   GRAMS/KM                                4.24              1.83              2.18               1.97
   CO2 GRAMS/KM                                206.9             185.8             176.0              180.3
   NOX GRAMS/KM                                 1.40               .95              1.33                .88
   FUEL CONSUMPTION BY CB L/100KM              19.84             17.39             16.54              16.89

   RUN TIME              SECONDS                505.              867.              505.               867.
   MEASURED DISTANCE     KM                     5.84              6.27              5.80               6.26
   SCF, DRY                                     .969      .974    .977              .972      .975     .977
         DFC, WET (DRY)                              .938( .927)                          .945( .934)
         TOT VOL (SCM) / SAM BLR (SCM)              202.4/  0.00                         202.3/  0.00
         KM  (MEASURED)                                12.10                                12.06
         FUEL CONSUMPTION L/100KM                      18.57                                16.72

COMPOSITE RESULTS                                                                              3-BAG      (4-BAG)
   TEST NUMBER         863FTP                                  CARBON DIOXIDE       G/KM      187.5     ( 185.9)
   BAROMETER    MM HG   729.7                                  FUEL CONSUMPTION     L/100KM   17.66     ( 17.51)
   HUMIDITY     G/KG      8.3                                  HYDROCARBONS (THC)   G/KM        .56     (   .56)
   TEMPERATURE  DEG C    26.1                                  CARBON MONOXIDE      G/KM       2.43     (  2.47)
                                                               OXIDES OF NITROGEN   G/KM       1.14     (  1.12)
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                                 HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                          PROJECT 05-6619-001

TEST NO.   863FET   RUN   1                 VEHICLE NO.86                        TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                DATE   12/22/81                      ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                  BAG CART NO.  1                      GASOLINE  EM-464-F
TRANSMISSION A3                             DYNO NO.      3                      ODOMETER  2969. KM( 1845. MILES)
                                            CVS NO.   2

BAROMETER 730.50 MM HG(28.76 IN HG)         DRY BULB TEMP. 26.1 DEG C(79.0 DEG F)
RELATIVE HUMIDITY  51. PCT                  ABS. HUMIDITY 11.2 GM/KG             NOX HUMIDITY CORRECTION FACTOR  1.01
BAG RESULTS
   TEST CYCLE                                     HFET

   BLOWER DIF P MM. H2O(IN. H2O)            774.7 (30.5)
   BLOWER INLET P MM. H2O(IN. H2O)          774.7 (30.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.2 (108.0)
   BLOWER REVOLUTIONS                          61270.
   TOT FLOW STD. CU. METRES(SCF)            114.6 ( 4046.)
   HC   SAMPLE METER/RANGE/PPM              25.0/ 2/  25.
   HC   BCKGRD METER/RANGE/PPM               9.2/ 2/   9.
   CO   SAMPLE METER/RANGE/PPM              64.5/11/ 262.
   CO   BCKGRD METER/RANGE/PPM               1.1/11/   3.
   CO2 SAMPLE METER/RANGE/PCT               68.1/ 3/ 1.23
   CO2 BCKGRD METER/RANGE/PCT                2.4/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               87.3/ 2/  87.
   NOX BCKGRD METER/RANGE/PPM                 .9/ 2/   1.
   DILUTION FACTOR                              9.24
   HC   CONCENTRATION PPM                        17.
   CO   CONCENTRATION PPM                       245.
   CO2 CONCENTRATION PCT                        1.19
   NOX CONCENTRATION PPM                        86.5
   HC   MASS GRAMS                              2.56
   CO   MASS GRAMS                             32.67
   CO2 MASS GRAMS                             2502.8
   NOX MASS GRAMS                              19.23
   RUN TIME              SECONDS                765.
         DFC, WET (DRY)                      .892 ( .877)
         SCF, WET (DRY)                     1.000 ( .959)
         VOL (SCM)                             114.6
         SAM BLR (SCM)                          0.00
         KM  (MEASURED)                        16.46

   TEST NUMBER,                                863FET
   BAROMETER,            MM HG                 730.5
   HUMIDITY,             G/KG                   11.2
   TEMPERATURE,          DEG C                  26.1
   CARBON DIOXIDE,       G/KM                  152.1
   FUEL CONSUMPTION,     L/100KM               14.29

   HYDROCARBONS,         G/KM                    .16
   CARBON MONOXIDE,      G/KM                   1.99
   OXIDES OF NITROGEN,   G/KM                   1.17
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TABLE D-19. TEST NO. 871 EMISSIONS RESULTS

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                                         FTP   - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                                 PROJECT 05-6619-001

TEST NO.   871FTP   RUN   1                      VEHICLE NO.87                       TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE   12/ 3/81                     ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO. 1 / CVS NO.  2         GASOLINE  EM-464-F
TRANSMISSION A3                                  DYNO NO.      3                     ODOMETER 10167. KM( 6317. MILES)

BAROMETER 744.22 MM HG(29.30 IN HG)              DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  26. PCT                       ABS. HUMIDITY  5.0 GM/KG            NOX HUMIDITY CORRECTION FACTOR   .84
BAG RESULTS
   BAG NUMBER                                          1                  2                  3                   4
   DESCRIPTION                                  COLD TRANSIENT       STABILIZED       HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)                787.4 (31.0)       787.4 (31.0)       787.4 (31.0)       784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)              787.4 (31.0)       787.4 (31.0)       787.4 (31.0)       784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)             42.8 (109.0)       42.2 (108.0)       42.8 (109.0)       42.8 (109.0)
   BLOWER REVOLUTIONS                              40476.             69516.             40455.             69472.
   TOT FLOW STD. CU. METRES(SCF)                75.9 ( 2681.)     130.5 ( 4609.)      75.9 ( 2680.)     130.4 ( 4603.)
   HC  SAMPLE METER/RANGE/PPM                  40.3/ 2/  40.      15.3/ 2/  15.      16.0/ 2/  16.      14.0/ 2/  14.
   HC  BCKGRD METER/RANGE/PPM                  13.0/ 2/  13.      11.8/ 2/  12.      12.2/ 2/  12.      11.2/ 2/  11.
   CO  SAMPLE METER/RANGE/PPM                  82.3/12/ 196.      19.5/13/  18.      50.3/13/  47.      21.4/13/  20.
   CO  BCKGRD METER/RANGE/PPM                   1.8/12/   3.       2.5/13/   2.       2.2/13/   2.       1.7/13/   2.
   CO2 SAMPLE METER/RANGE/PCT                  55.5/ 3/  .97      34.7/ 3/  .58      47.7/ 3/  .82      34.1/ 3/  .57
   CO2 BCKGRD METER/RANGE/PCT                   3.1/ 3/  .05       3.1/ 3/  .05       3.5/ 3/  .05       2.8/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                  33.6/ 2/  34.       2.9/ 2/   3.      11.2/ 2/  11.       2.7/ 2/   3.
   NOX BCKGRD METER/RANGE/PPM                    .7/ 2/   1.        .4/ 2/   0.        .5/ 2/   1.        .5/ 2/   1.
   DILUTION FACTOR                                 11.61              19.84              13.97              20.22
   HC  CONCENTRATION PPM                           28.                 4.                 5.                 3.
   CO  CONCENTRATION PPM                          186.                15.                44.                18.
   CO2 CONCENTRATION PCT                           .93                .54                .77                .53
   NOX CONCENTRATION PPM                          33.0                2.5               10.7                2.2
   HC  MASS GRAMS                                 2.87                .71                .47                .58
   CO  MASS GRAMS                                16.43               2.30               3.89               2.67
   CO2 MASS GRAMS                               1293.8             1279.0             1074.2             1261.8
   NOX MASS GRAMS                                 4.03                .53               1.31                .47

   HC  GRAMS/KM                                    .50                .11                .08                .09
   CO  GRAMS/KM                                   2.86                .37                .68                .43
   CO2 GRAMS/KM                                  225.3              205.1              186.9              202.8
   NOX GRAMS/KM                                    .70                .08                .23                .08
   FUEL CONSUMPTION BY CB L/100KM                21.19              18.92              17.29              18.72

   RUN TIME            SECONDS                    505.               867.               505.               868.
   MEASURED DISTANCE    KM                        5.74               6.24               5.75               6.22
   SCF, DRY                                       .972      .977      .980             .975      .978     .980
        DFC, WET (DRY)                                 .936( .929)                          .942( .935)
        TOT VOL (SCM) / SAM BLR (SCM)                206.5/  0.00                         206.2/  0.00
        KM  (MEASURED)                                  11.98                                11.97
        FUEL CONSUMPTION L/100KM                        20.01                                18.03

COMPOSITE RESULTS
   TEST NUMBER           871FTP                                                                3-BAG        (4-BAG)
   BAROMETER     MM HG   744.2                            CARBON DIOXIDE        G/KM          204.2        ( 205.6)
   HUMIDITY      G/KG      5.0                            FUEL CONSUMPTION      L/100KM       18.94        ( 18.88)
   TEMPERATURE   DEG C    24.4                            HYDROCARBONS (THC)    G/KM            .19        (    .18)
                                                          CARBON MONOXIDE       G/KM            .97        (    .98)
                                                          OXIDES OF NITROGEN    G/KM            .25        (    .25)
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                                         HFET  - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                                 PROJECT 05-6619-001

TEST NO.   874FET   RUN   1                      VEHICLE NO.87                       TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE   12/ 7/81                     ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO.  1                     GASOLINE  EM-464-F
TRANSMISSION A3                                  DYNO NO.      3                     ODOMETER 10306. KM( 6404. MILES)
                                                 CVS NO.   2

BAROMETER 741.17 MM HG(29.18 IN HG)              DRY BULB TEMP. 25.6 DEG C(78.0 DEG F)
RELATIVE HUMIDITY  58. PCT                       ABS. HUMIDITY 10.5 GM/KG            NOX HUMIDITY CORRECTION FACTOR   .99
BAG RESULTS
   TEST CYCLE                                       HFET

   BLOWER DIF P MM. H2O(IN. H2O)                800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)              800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)             41.1 (106.0)
   BLOWER REVOLUTIONS                              61241.
   TOT FLOW STD. CU. METRES(SCF)                116.1 ( 4101.)
   HC  SAMPLE METER/RANGE/PPM                  10.9/ 2/  11.
   HC  BCKGRD METER/RANGE/PPM                  10.7/ 2/  11.
   CO  SAMPLE METER/RANGE/PPM                   9.8/13/   9.
   CO  BCKGRD METER/RANGE/PPM                   3.6/13/   3.
   CO2 SAMPLE METER/RANGE/PCT                  61.4/ 3/ 1.09
   CO2 BCKGRD METER/RANGE/PCT                   3.1/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                  11.4/ 2/  11.
   NOX BCKGRD METER/RANGE/PPM                    .7/ 2/   1.
   DILUTION FACTOR                                 10.60
   HC  CONCENTRATION PPM                            1.
   CO  CONCENTRATION PPM                            6.
   CO2 CONCENTRATION PCT                          1.09
   NOX CONCENTRATION PPM                          10.8
   HC  MASS GRAMS                                  .19
   CO  MASS GRAMS                                  .75
   CO2 MASS GRAMS                               2228.2
   NOX MASS GRAMS                                 2.37
   RUN TIME                SECONDS                765.
        DFC, WET (DRY)                          .906 ( .891)
        SCF, WET (DRY)                         1.000 ( .962)
        VOL (SCM)                                116.1
        SAM BLR (SCM)                             0.00
        KM  (MEASURED)                           16.39

   TEST NUMBER,                                  874FET
   BAROMETER,              MM HG                  741.2
   HUMIDITY,               G/KG                    10.5
   TEMPERATURE,            DEG C                   25.6
   CARBON DIOXIDE,         G/KM                   136.0
   FUEL CONSUMPTION,       L/100KM                12.51

   HYDROCARBONS,           G/KM                     .01
   CARBON MONOXIDE,        G/KM                     .05
   OXIDES OF NITROGEN,     G/KM                     .14
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TABLE D-20. TEST NO. 872 EMISSIONS RESULTS

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                                   FTP   - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                             PROJECT 05-6619-001

TEST NO.   872FTP   RUN   1                  VEHICLE NO.87                    TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT               DATE   12/ 4/81                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4             .     BAG CART NO. 1 / CVS NO.  2      GASOLINE  EM-464-F
TRANSMISSION A3                              DYNO NO.      3                  ODOMETER 10208. KM( 6343. MILES)

BAROMETER 754.89 MM HG(29.72 IN HG)          DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  26. PCT                   ABS. HUMIDITY  4.9 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .84
BAG RESULTS
   BAG NUMBER                                      1                2                3                4
   DESCRIPTION                              COLD TRANSIENT     STABILIZED      HOT TRANSIENT      STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)            800.1 (31.5)     800.1 (31.5)     800.1 (31.5)      787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)          800.1 (31.5)     800.1 (31.5)     800.1 (31.5)      787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)         41.7 (107.0)     41.1 (106.0)     42.8 (109.0)      42.8 (109.0)
   BLOWER REVOLUTIONS                          40405.           69554.           40368.            69461.
   TOT FLOW STD. CU. METRES(SCF)            77.0 ( 2719.)    132.7 ( 4686.)   76.8 ( 2713.)     132.4 ( 4674.)
   HC   SAMPLE METER/RANGE/PPM              46.3/ 2/  46.    11.4/ 2/  11.    11.6/ 2/  12.     10.0/ 2/  10.
   HC   BCKGRD METER/RANGE/PPM               9.3/ 2/   9.     8.6/ 2/   9.     8.0/ 2/   8.      7.5/ 2/   8.
   CO   SAMPLE METER/RANGE/PPM              75.0/12/ 174.    21.9/13/  20.    35.6/13/  33.      9.7/13/   9.
   CO   BCKGRD METER/RANGE/PPM               1.0/12/   2.     1.7/13/   2.     1.1/13/   1.      1.2/13/   1.
   CO2  SAMPLE METER/RANGE/PCT              53.9/ 3/  .94    33.6/ 3/  .56    43.7/ 3/  .75     33.0/ 3/  .55
   CO2  BCKGRD METER/RANGE/PCT               2.5/ 3/  .04     2.9/ 3/  .04     2.9/ 3/  .04      2.8/ 3/  .04
   NOX  SAMPLE METER/RANGE/PPM              24.1/ 2/  24.     2.4/ 2/   2.     7.9/ 2/   8.      2.8/ 2/   3.
   NOX  BCKGRD METER/RANGE/PPM                .2/ 2/   0.      .3/ 2/   0.      .3/ 2/   0.       .2/ 2/   0.
   DILUTION FACTOR                              12.01            20.55            15.41             21.00
   HC   CONCENTRATION PPM                       38.               3.               4.                3.
   CO   CONCENTRATION PPM                      166.              18.              31.                8.
   CO2  CONCENTRATION PCT                       .91              .52              .71               .51
   NOX  CONCENTRATION PPM                      23.9              2.1              7.6               2.6
   HC   MASS GRAMS                             3.88              .57              .42               .50
   CO   MASS GRAMS                            14.87             2.78             2.77              1.16
   CO2  MASS GRAMS                           1280.0           1258.8            992.3            1232.7
   NOX  MASS GRAMS                             2.96              .45              .94               .55

   HC   GRAMS/KM                                .68              .09              .07               .08
   CO   GRAMS/KM                               2.60              .45              .48               .19
   CO2  GRAMS/KM                              223.6            204.8            172.8             198.7
   NOX  GRAMS/KM                                .52              .07              .16               .09
   FUEL CONSUMPTION BY CB L/100KM             21.02            18.91            15.97             18.30

   RUN TIME                 SECONDS            504.             868.             504.              868.
   MEASURED DISTANCE        KM                 5.72             6.15             5.74              6.20
   SCF, DRY                                    .973      .978    .981             .977      .979    .981
        DFC, WET (DRY)                            .939( .931)                       .946( .938)
        TOT VOL (SCM) / SAM BLR (SCM)             209.7/  0.00                      209.2/  0.00
        KM  (MEASURED)                               11.87                             11.95
        FUEL CONSUMPTION L/100KM                     19.93                             17.18

COMPOSITE RESULTS
   TEST NUMBER            872FTP                                                          3-BAG       (4-BAG)
   BAROMETER    MM HG   754.9                           CARBON DIOXIDE          G/KM      199.9      ( 198.1)
   HUMIDITY     G/KG      4.9                           FUEL CONSUMPTION        L/100KM   18.54      ( 18.36)
   TEMPERATURE  DEG C    24.4                           HYDROCARBONS (THC)      G/KM        .21      (    .21)
                                                        CARBON MONOXIDE         G/KM        .91      (    .83)
                                                        OXIDES OF NITROGEN      G/KM        .19      (    .19)
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                                   HFET  - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                             PROJECT 05-6619-001

TEST NO.   872FET   RUN   1                  VEHICLE NO.87
VEHICLE MODEL   81 FORD ESCORT               DATE   12/ 4/81                  TEST WEIGHT  1134. KG( 2500. LBS)
ENGINE 1.6 L( 98. CID) L-4                   BAG CART NO.  1                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
TRANSMISSION A3                              DYNO NO.      3                  GASOLINE  EM-465-F
                                             CVS NO.   2                      ODOMETER 10233. KM( 6359. MILES)

BAROMETER 754.63 MM HG(29.71 IN HG)          DRY BULB TEMP. 27.2 DEG C(81.0 DEG F)
RELATIVE HUMIDITY  17. PCT                   ABS. HUMIDITY  3.7 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .81
BAG RESULTS
   TEST CYCLE                                  HFET

   BLOWER DIF P MM. H2O(IN. H2O)            812.8 (32.0)
   BLOWER INLET P MM. H2O(IN. H2O)          812.8 (32.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.8 (109.0)
   BLOWER REVOLUTIONS                          61210.
   TOT FLOW STD. CU. METRES(SCF)            118.0 ( 4167.)
   HC   SAMPLE METER/RANGE/PPM                9.3/ 2/   9.
   HC   BCKGRD METER/RANGE/PPM                7.1/ 2/   7.
   CO   SAMPLE METER/RANGE/PPM               13.2/13/  12.
   CO   BCKGRD METER/RANGE/PPM                 .6/13/   1.
   CO2  SAMPLE METER/RANGE/PCT               60.0/ 3/ 1.06
   CO2  BCKGRD METER/RANGE/PCT                2.9/ 3/  .04
   NOX  SAMPLE METER/RANGE/PPM               13.2/ 2/  13.
   NOX  BCKGRD METER/RANGE/PPM                 .4/ 2/   0.
   DILUTION FACTOR                              10.87
   HC   CONCENTRATION PPM                        3.
   CO   CONCENTRATION PPM                       11.
   CO2  CONCENTRATION PCT                       1.02
   NOX  CONCENTRATION PPM                       12.8
   HC   MASS GRAMS                               .45
   CO   MASS GRAMS                              1.51
   CO2  MASS GRAMS                            2209.4
   NOX  MASS GRAMS                              2.36
   RUN TIME                 SECONDS             765.
        DFC, WET (DRY)                       .908 ( .903)
        SCF, WET (DRY)                      1.000 ( .973)
        VOL (SCM)                              118.0
        SAM BLR (SCM)                           0.00
        KM  (MEASURED)                         16.25

   TEST NUMBER,                                872FET
   BAROMETER,               MM HG              754.6
   HUMIDITY,                G/KG                 3.7
   TEMPERATURE,             DEG C               27.2
   CARBON DIOXIDE,          G/KM               136.0
   FUEL CONSUMPTION,        L/100KM            12.52

   HYDROCARBONS,            G/KM                 .03
   CARBON MONOXIDE,         G/KM                 .09
   OXIDES OF NITROGEN,      G/KM                 .14
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TABLE D-21. TEST NO. 873 EMISSIONS RESULTS

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                              FTP   - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                       PROJECT 05-6619-001

TEST NO.   873FTP   RUN   1              VEHICLE NO.87                    TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT           DATE   12/ 7/81                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4               BAG CART NO. 1 / CVS NO.  2      GASOLINE  EM-464-F
TRANSMISSION A3                          DYNO NO.      3                  ODOMETER 10264. KM( 6378. MILES)

BAROMETER 740.66 MM HG(29.16 IN HG)      DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  53. PCT               ABS. HUMIDITY 10.7 GM/KG         NOX HUMIDITY CORRECTION FACTOR  1.00
BAG RESULTS
   BAG NUMBER                                  1                  2                  3                  4
   DESCRIPTION                          COLD TRANSIENT        STABILIZED       HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)         792.5 (31.2)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)       792.5 (31.2)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)      42.2 (108.0)       41.7 (107.0)       41.7 (107.0)       41.7 (107.0)
   BLOWER REVOLUTIONS                      40464.             69560.             40439.             69477.
   TOT FLOW STD. CU. METRES(SCF)         75.5 ( 2666.)      130.0 ( 4591.)      75.6 ( 2669.)      129.9 ( 4585.)
   HC  SAMPLE METER/RANGE/PPM           46.3/ 2/  46.      14.8/ 2/  15.      15.0/ 2/  15.      12.6/ 2/  13.
   HC  BCKGRD METER/RANGE/PPM           14.3/ 2/  14.      13.4/ 2/  13.      12.8/ 2/  13.      12.0/ 2/  12.
   CO  SAMPLE METER/RANGE/PPM           85.6/12/ 207.      26.5/13/  24.      43.1/13/  40.      13.2/13/  12.
   CO  BCKGRD METER/RANGE/PPM            3.8/12/   7.       7.4/13/   7.       6.6/13/   6.       6.0/13/   5.
   CO2 SAMPLE METER/RANGE/PCT           53.3/ 3/  .93      34.8/ 3/  .58      45.7/ 3/  .78      33.9/ 3/  .57
   CO2 BCKGRD METER/RANGE/PCT            3.2/ 3/  .05       3.3/ 3/  .05       3.3/ 2/  .12       3.1/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM           26.0/ 2/  26.       2.5/ 2/   3.       7.1/ 2/   7.       2.6/ 2/   3.
   NOX BCKGRD METER/RANGE/PPM             .7/ 2/   1.        .7/ 2/   1.        .5/ 2/   1.        .4/ 2/   0.
   DILUTION FACTOR                          12.12              19.76              14.65              20.38
   HC  CONCENTRATION PPM                     33.                2.                 3.                 1.
   CO  CONCENTRATION PPM                    191.               17.                33.                 6.
   CO2 CONCENTRATION PCT                     .89                .53                .68                .52
   NOX CONCENTRATION PPM                    25.4                1.8                6.6                2.2
   HC  MASS GRAMS                            3.34               .36                .31                .21
   CO  MASS GRAMS                           16.80              2.60               2.92                .98
   CO2 MASS GRAMS                          1225.0            1271.4              934.2             1237.8
   NOX MASS GRAMS                            3.66               .46                .96                .55

   HC  GRAMS/KM                              .58                .06                .05                .03
   CO  GRAMS/KM                             2.91                .41                .50                .16
   CO2 GRAMS/KM                            212.0              202.5              160.5              197.8
   NOX GRAMS/KM                              .63                .07                .16                .09
   FUEL CONSUMPTION BY CB L/100KM          19.99              18.68              14.84              18.22

   RUN TIME              SECONDS            504.               868.               505.               867.
   MEASURED DISTANCE     KM                 5.78               6.28               5.82               6.26
   SCF, DRY                                 .964     .969      .971               .967     .970      .972
         DFC, WET (DRY)                          .938( .922)                          .944( .928)
         TOT VOL (SCM) / SAM BLR (SCM)           205.5/  0.00                         205.4/  0.00
         KM  (MEASURED)                             12.06                                12.08
         FUEL CONSUMPTION L/100KM                   19.31                                16.59

COMPOSITE RESULTS                                                                       3-BAG      (4-BAG)
   TEST NUMBER          873FTP                         CARBON DIOXIDE       G/KM       192.9     ( 191.5)
   BAROMETER    MM HG  740.7                           FUEL CONSUMPTION     L/100KM    17.90     ( 17.76)
   HUMIDITY     G/KG    10.7                           HYDROCARBONS (THC)   G/KM         .16     (   .16)
   TEMPERATURE  DEG C   25.0                           CARBON MONOXIDE      G/KM         .95     (   .88)
                                                       OXIDES OF NITROGEN   G/KM         .21     (   .22)
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                              HFET  - VEHICLE EMISSIONS RESULTS -METHANOL -BASE METAL
                                       PROJECT 05-6619-001

TEST NO.   873FET   RUN   1              VEHICLE NO.87                    TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT           DATE   12/ 7/81                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4               BAG CART NO.  1                  GASOLINE  EM-464-F
TRANSMISSION A3                          DYNO NO.      3                  ODOMETER 10289. KM( 6393. MILES)
                                         CVS NO.   2

BAROMETER 740.92 MM HG(29.17 IN HG)      DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  49. PCT               ABS. HUMIDITY 10.0 GM/KG         NOX HUMIDITY CORRECTION FACTOR   .98
BAG RESULTS
   TEST CYCLE                               HFET

   BLOWER DIF P MM. H2O(IN. H2O)         800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)       800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)      42.2 (108.0)
   BLOWER REVOLUTIONS                      61246.
   TOT FLOW STD. CU. METRES(SCF)        115.9 ( 4092.)
   HC  SAMPLE METER/RANGE/PPM           11.5/ 2/  12.
   HC  BCKGRD METER/RANGE/PPM           11.3/ 2/  11.
   CO  SAMPLE METER/RANGE/PPM           12.2/13/  11.
   CO  BCKGRD METER/RANGE/PPM            4.7/13/   4.
   CO2 SAMPLE METER/RANGE/PCT           61.1/ 3/ 1.08
   CO2 BCKGRD METER/RANGE/PCT            3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM           10.9/ 2/  11.
   NOX BCKGRD METER/RANGE/PPM             .5/ 2/   1.
   DILUTION FACTOR                          10.65
   HC  CONCENTRATION PPM                     1.
   CO  CONCENTRATION PPM                     7.
   CO2 CONCENTRATION PCT                    1.04
   NOX CONCENTRATION PPM                    10.4
   HC  MASS GRAMS                            .19
   CO  MASS GRAMS                            .91
   CO2 MASS GRAMS                          2213.3
   NOX MASS GRAMS                           2.26
   RUN TIME               SECONDS           765.
         DFC, WET (DRY)                  .906 ( .892)
         SCF, WET (DRY)                 1.000 ( .962)
         VOL (SCM)                         115.9
         SAM BLR (SCM)                      0.00
         KM  (MEASURED)                    16.31

   TEST NUMBER,                            873FET
   BARAMETER,            MM HG              740.9
   HUMIDITY,             G/KG               10.0
   TEMPERATURE,          DEG C              25.0
   CARBON DIOXIDE,       G/KM              135.7
   FUEL CONSUMPTION,     L/100KM            12.48

   HYDROCARBONS,         G/KM                .01
   CARBON MONOXIDE,      G/KM                .06
   OXIDES OF NITROGEN,   G/KM                .14
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TABLE D-22. TEST NO. 881 EMISSIONS RESULTS

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                                          FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                  PROJECT 05-6619-003

TEST NO.   881FTP   RUN   1                      VEHICLE NO.88                     TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE    1/ 8/82                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO. 1 / CVS NO.  2       GASOLINE  EM-464-F
TRANSMISSION A3                                  DYNO NO.      3                   ODOMETER 10896. KM( 6770. MILES)

BAROMETER 752.09 MM HG(29.61 IN HG)              DRY BULB TEMP. 20.6 DEG C(69.0 DEG F)
RELATIVE HUMIDITY  25. PCT                       ABS. HUMIDITY  3.8 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .81
BAG RESULTS
   BAG NUMBER                                          1                 2                 3                 4
   DESCRIPTION                                  COLD TRANSIENT      STABILIZED      HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)                 789.9 (31.1)      789.9 (31.1)      784.9 (30.9)      787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)               787.4 (31.0)      787.4 (31.0)      784.9 (30.9)      787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)              42.8 (109.0)      41.1 (106.0)      42.8 (109.0)      41.1 (106.0)
   BLOWER REVOLUTIONS                              40522.            69590.            40445.            69486.
   TOT FLOW STD. CU. METRES(SCF)                  76.9 ( 2715.)    132.4 ( 4676.)     76.8 ( 2711.)    132.2 ( 4669.)
   HC  SAMPLE METER/RANGE/PPM                    29.0/ 3/ 290.     24.7/ 3/ 247.     21.9/ 3/ 219.     20.5/ 3/ 205.
   HC  BCKGRD METER/RANGE/PPM                     1.3/ 3/  13.      1.3/ 3/  13.      1.2/ 3/  12.      1.2/ 3/  12.
   CO  SAMPLE METER/RANGE/PPM                    53.8/ 3/1330.     46.6/ 3/1130.     46.6/ 3/1130.     42.7/ 3/1025.
   CO  BCKGRD METER/RANGE/PPM                      .2/ 3/   5.       .3/ 3/   7.       .4/ 3/   9.       .2/ 3/   5.
   CO2 SAMPLE METER/RANGE/PCT                    44.5/ 3/  .76     27.8/ 3/  .46     37.9/ 3/  .64     28.9/ 3/  .48
   CO2 BCKGRD METER/RANGE/PCT                     3.0/ 3/  .05      2.6/ 3/  .04      2.9/ 3/  .04      3.3/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                    39.9/ 2/  40.      8.7/ 2/   9.     16.2/ 2/  16.      7.1/ 2/   7.
   NOX BCKGRD METER/RANGE/PPM                      .2/ 2/   0.       .3/ 2/   0.       .5/ 2/   1.       .6/ 2/   1.
   DILUTION FACTOR                                  12.59             19.56             15.03             19.40
   HC  CONCENTRATION PPM                            278.              235.              208.              194.
   CO  CONCENTRATION PPM                           1285.             1099.             1091.              998.
   CO2 CONCENTRATION PCT                             .72               .42               .60               .43
   NOX CONCENTRATION PPM                            39.7               8.4              15.7               6.5
   HC  MASS GRAMS                                   28.47             41.39             21.25             34.10
   CO  MASS GRAMS                                  114.98            169.40             97.47            153.65
   CO2 MASS GRAMS                                  1013.3            1015.8             839.7            1036.6
   NOX MASS GRAMS                                    4.76              1.74              1.88              1.35

   HC  GRAMS/KM                                      4.94              6.74              3.67              5.49
   CO  GRAMS/KM                                     19.95             27.58             16.84             24.72
   CO2 GRAMS/KM                                     175.9             165.4             145.1             166.8
   NOX GRAMS/KM                                       .83               .28               .33               .22
   FUEL CONSUMPTION BY CB L/100KM                   19.67             20.04             16.23             19.60

   RUN TIME            SECONDS                      505.              868.              505.              868.
   MEASURED DISTANCE    KM                          5.76              6.14              5.79              6.22
   SCF, DRY                                         .977      .980     .983             .979      .981     .982
        DFC, WET (DRY)                                    .941( .934)                         .944( .936)
        TOT VOL (SCM) / SAM BLR (SCM)                    209.3/  0.00                        209.0/  0.00
        KM  (MEASURED)                                      11.90                               12.01
        FUEL CONSUMPTION L/100KM                            19.86                               17.97

COMPOSITE RESULTS                                                                                  3-BAG      (4-BAG)
   TEST NUMBER          881FTP                                  CARBON DIOXIDE       G/KM          161.9     ( 162.4)
   BAROMETER    MM HG   752.1                                   FUEL CONSUMPTION     L/100KM        18.91     ( 18.79)
   HUMIDITY     G/KG      3.8                                   HYDROCARBONS (THC)   G/KM            5.52     (  5.15)
   TEMPERATURE  DEC C    20.6                                   CARBON MONOXIDE      G/KM           23.02     ( 22.19)
                                                                OXIDES OF NITROGEN   G/KM             .41     (   .39)
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                                          HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                  PROJECT 05-6619-003

TEST NO.   881FET   RUN   1                      VEHICLE NO.88                     TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                   DATE    1/ 8/82                   ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                       BAG CART NO.  1                   GASOLINE  EM-464-F
TRANSMISSION A3                                  DYNO NO.      3                   ODOMETER 10920. KM( 6786. MILES)
                                                 CVS NO.   2

BAROMETER 752.35 MM HG(29.62 IN HG)              DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  18. PCT                       ABS. HUMIDITY  3.6 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .81
BAG RESULTS
   TEST CYCLE                                         HFET

   BLOWER DIF P MM. H2O(IN. H2O)                 800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)               792.5 (31.2)
   BLOWER INLET TEMP. DEG. C(DEG. F)              43.3 (110.0)
   BLOWER REVOLUTIONS                              61293.
   TOT FLOW STD. CU. METRES(SCF)                 118.2 ( 4175.)
   HC  SAMPLE METER/RANGE/PPM                    27.3/ 3/ 273.
   HC  BCKGRD METER/RANGE/PPM                     1.1/ 3/  11.
   CO  SAMPLE METER/RANGE/PPM                    28.5/ 3/ 664.
   CO  BCKGRD METER/RANGE/PPM                      .3/ 3/   7.
   CO2 SAMPLE METER/RANGE/PCT                    57.8/ 3/ 1.02
   CO2 BCKGRD METER/RANGE/PCT                     3.4/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                    17.8/ 2/  18.
   NOX BCKGRD METER/RANGE/PPM                      .7/ 2/   1.
   DILUTION FACTOR                                  10.43
   HC  CONCENTRATION PPM                            263.
   CO  CONCENTRATION PPM                            634.
   CO2 CONCENTRATION PCT                             .97
   NOX CONCENTRATION PPM                            17.2
   HC  MASS GRAMS                                   41.43
   CO  MASS GRAMS                                   87.27
   CO2 MASS GRAMS                                  2104.7
   NOX MASS GRAMS                                    3.14
   RUN TIME                 SECONDS                 766.
        DFC, WET (DRY)                           .904 ( .899)
        SCF, WET (DRY)                          1.000 ( .974)
        VOL (SCM)                                  118.2
        SAM BLR (SCM)                               0.00
        KM  (MEASURED)                             16.53

   TEST NUMBER,                                    881FET
   BAROMETER,             MM HG                     752.3
   HUMIDITY,              G/KG                        3.6
   TEMPERATURE,           DEG C                      25.0
   CARBON DIOXIDE,        G/KM                      127.4
   FUEL CONSUMPTION,      L/100KM                   12.79

   HYDROCARBONS,          G/KM                       2.91
   CARBON MONOXIDE,       G/KM                       5.28
   OXIDES OF NITROGEN,    G/KM                        .19
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TABLE D-23. TEST NO. 882 EMISSIONS RESULTS

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                                   FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                            PROJECT 05-6619-003

TEST NO.   882FTP   RUN   1                   VEHICLE NO.88                     TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                DATE     1/11/82                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                    BAG CART NO. 1 / CVS NO.  2       GASOLINE  EM-464-F
TRANSMISSION A3                               DYNO NO.      3                   ODOMETER 10950. KM( 6804. MILES)

BAROMETER 752.86 MM HG(29.64 IN HG)           DRY BULB TEMP. 21.7 DEG C(71.0 DEG F)
RELATIVE HUMIDITY  11. PCT                    ABS. HUMIDITY  1.8 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .77
BAG RESULTS
   BAG NUMBER                                      1                 2                  3                  4
   DESCRIPTION                               COLD TRANSIENT      STABILIZED        HOT TRANSIENT       STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)             787.4 (31.0)       800.1 (31.5)       800.1 (31.5)       800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)           787.4 (31.0)       800.1 (31.5)       800.1 (31.5)       800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)          43.3 (110.0)       40.6 (105.0)       42.2 (108.0)       41.1 (106.0)
   BLOWER REVOLUTIONS                          40458.             69578.             40396.             69564.
   TOT FLOW STD. CU. METRES(SCF)              76.8 ( 2711.)     132.4 ( 4677.)      76.7 ( 2707.)     132.3 ( 4671.)
   HC  SAMPLE METER/RANGE/PPM                34.0/ 3/ 340.      33.5/ 3/ 335.      27.1/ 3/ 271.      20.3/ 3/ 203.
   HC  BCKGRD METER/RANGE/PPM                 1.0/ 3/  10.       1.0/ 3/  10.       1.0/ 3/  10.        .9/ 3/   9.
   CO  SAMPLE METER/RANGE/PPM                57.6/ 3/1440.      57.4/ 3/1434.      52.8/ 3/1301.      48.6/ 3/1184.
   CO  BCKGRD METER/RANGE/PPM                  .7/ 3/  16.        .7/ 3/  16.        .4/ 3/   9.        .4/ 3/   9.
   CO2 SAMPLE METER/RANGE/PCT                45.6/ 3/  .78      27.2/ 3/  .45      37.6/ 3/  .63      28.8/ 3/  .47
   CO2 BCKGRD METER/RANGE/PCT                 3.6/ 3/  .06       3.3/ 3/  .05       3.2/ 3/  .05       3.0/ 3/  .05
   NOX SAMPLE METER/RANGE/PPM                41.0/ 2/  41.       7.5/ 2/   8.      13.7/ 2/  14.       7.1/ 2/   7.
   NOX BCKGRD METER/RANGE/PPM                  .7/ 2/   1.        .4/ 2/   0.        .4/ 2/   0.        .5/ 2/   1.
   DILUTION FACTOR                              12.10              18.66              14.70              18.95
   HC  CONCENTRATION PPM                        331.               326.               262.               194.
   CO  CONCENTRATION PPM                        1386.              1395.              1264.              1155.
   CO2 CONCENTRATION PCT                         .73                .40                .59                .43
   NOX CONCENTRATION PPM                        40.4                7.1               13.3                6.6
   HC  MASS GRAMS                               33.83              57.43              26.72              34.26
   CO  MASS GRAMS                              123.90             215.04             112.78             177.82
   CO2 MASS GRAMS                              1029.3              965.7              824.8             1043.4
   NOX MASS GRAMS                                4.58               1.39               1.51               1.30

   HC  GRAMS/KM                                  5.85               9.21               4.61               5.49
   CO  GRAMS/KM                                 21.44              34.48              19.44              28.48
   CO2 GRAMS/KM                                 178.1              154.8              142.2              167.1
   NOX GRAMS/KM                                   .79                .22                .26                .21
   FUEL CONSUMPTION BY CB L/100KM               20.22              20.38              16.46              20.17

   RUN TIME              SECONDS                504.               868.               504.               869.
   MEASURED DISTANCE     KM                     5.78               6.24               5.80               6.24
   SCF, DRY                                     .981      .985     .987               .984      .986     .987
        DFC, WET (DRY)                                .938( .935)                           .943( .939)
        TOT VOL (SCM) / SAM BLR (SCM)                209.2/  0.00                          208.9/  0.00
        KM  (MEASURED)                                  12.01                                 12.05
        FUEL CONSUMPTION L/100KM                        20.30                                 18.39

COMPOSITE RESULTS                                                                          3-BAG       (4-BAG)
   TEST NUMBER          882FTP                              CARBON DIOXIDE       G/KM      156.2      ( 159.8)
   BAROMETER    MM HG   752.9                               FUEL CONSUMPTION     L/100KM   19.27      ( 19.21)
   HUMIDITY     G/KG      1.8                               HYDROCARBONS (THC)   G/KM       7.25      (  6.15)
   TEMPERATURE  DEG C    21.7                               CARBON MONOXIDE      G/KM      27.65      ( 25.88)
                                                            OXIDES OF NITROGEN   G/KM        .35      (   .35)
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                                   HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                            PROJECT 05-6619-003

TEST NO.   882FET   RUN   1                   VEHICLE NO.88                     TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                DATE     1/11/82                  ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                    BAG CART NO.  1                   GASOLINE  EM-464-F
TRANSMISSION A3                               DYNO NO.      3                   ODOMETER 10975. KM( 6820. MILES)
                                              CVS NO.   2

BAROMETER 752.09 MM HG(29.61 IN HG)           DRY BULB TEMP. 22.2 DEG C(72.0 DEG F)
RELATIVE HUMIDITY  12. PCT                    ABS. HUMIDITY  2.1 GM/KG          NOX HUMIDITY CORRECTION FACTOR   .78
BAG RESULTS
   TEST CYCLE                                    HFET

   BLOWER DIF P MM. H2O(IN. H2O)              810.3 (31.9)
   BLOWER INLET P MM. H2O(IN. H2O)            807.7 (31.8)
   BLOWER INLET TEMP. DEG. C(DEG. F)           43.3 (110.0)
   BLOWER REVOLUTIONS                           61213.
   TOT FLOW STD. CU. METRES(SCF)              117.4 ( 4147.)
   HC  SAMPLE METER/RANGE/PPM                 26.6/ 3/ 266.
   HC  BCKGRD METER/RANGE/PPM                  1.0/ 3/  10.
   CO  SAMPLE METER/RANGE/PPM                 29.7/ 3/ 694.
   CO  BCKGRD METER/RANGE/PPM                   .7/ 3/  16.
   CO2 SAMPLE METER/RANGE/PCT                 56.1/ 3/  .99
   CO2 BCKGRD METER/RANGE/PCT                  2.9/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                 16.6/ 2/  17.
   NOX BCKGRD METER/RANGE/PPM                   .4/ 2/   0.
   DILUTION FACTOR                               10.73
   HC  CONCENTRATION PPM                         257.
   CO  CONCENTRATION PPM                         656.
   CO2 CONCENTRATION PCT                          .95
   NOX CONCENTRATION PPM                         16.2
   HC  MASS GRAMS                                40.19
   CO  MASS GRAMS                                89.71
   CO2 MASS GRAMS                               2033.1
   NOX MASS GRAMS                                 2.84
   RUN TIME              SECONDS                 765.
        DFC, WET (DRY)                        .907 ( .903)
        SCF, WET (DRY)                       1.000 ( .976)
        VOL (SCM)                                117.4
        SAM BLR (SCM)                             0.00
        KM  (MEASURED)                           16.44

   TEST NUMBER,                                 882FET
   BAROMETER,              MM HG                 752.1
   HUMIDITY,               G/KG                    2.1
   TEMPERATURE,            DEG C                  22.2
   CARBON DIOXIDE,         G/KM                  123.7
   FUEL CONSUMPTION,       L/100KM               12.47

   HYDROCARBONS,           G/KM                   2.45
   CARBON MONOXIDE,        G/KM                   5.46
   OXIDES OF NITROGEN,     G/KM                    .17
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TABLE D-24. TEST NO. 891 EMISSIONS RESULTS

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                                        TP   - VEHICLE EMISSIONS RESULTS -METHANOL
                                                PROJECT 05-6619-001

TEST NO.   891       RUN   1                 VEHICLE NO.84                   TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                 DATE    1/28/82                 ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                   BAG CART NO. 1 / CVS NO.  2     GASOLINE  EM-464-F
TRANSMISSION A3                              DYNO NO.     3                  ODOMETER  3757. KM( 2334. MILES)

BAROMETER 745.74 MM HG(29.36 IN HG)          DRY BULB TEMP. 21.7 DEG C(71.0 DEG F)
RELATIVE HUMIDITY  69. PCT                   ABS. HUMIDITY 11.4 GM/KG        NOX HUMIDITY CORRECTION FACTOR  1.02
BAG RESULTS
   BAG NUMBER                                    1                    2                    3                    4
   DESCRIPTION                             COLD TRANSIENT        STABILIZED         HOT TRANSIENT          STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)           800.1 (31.5)        795.0 (31.3)        792.5 (31.2)        787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)         787.4 (31.0)        787.4 (31.0)        787.4 (31.0)        787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)        43.3 (110.0)        42.2 (108.0)        42.8 (109.0)        42.6 (109.0)
   BLOWER REVOLUTIONS                         40468.              69580.              40406.              69483.
   TOT FLOW STD. CU. METRES(SCF)           76.0 ( 2683.)       130.9 ( 4622.)      75.9 ( 2682.)       130.6 ( 4612.)
   HC  SAMPLE METER/RANGE/PPM              75.8/ 2/  76.        9.5/ 2/  10.       12.0/ 2/  12.        8.5/ 2/   9.
   HC  BCKGRD METER/RANGE/PPM               8.4/ 2/   8.        8.3/ 2/   8.        7.5/ 2/   8.        7.4/ 2/   7.
   CO  SAMPLE METER/RANGE/PPM              60.4/11/ 238.       56.5/13/  54.       89.2/13/  90.       55.6/13/  53.
   CO  BCKGRD METER/RANGE/PPM                .9/11/   3.        2.2/13/   2.        2.5/13/   2.        1.4/13/   1.
   CO2 SAMPLE METER/RANGE/PCT              49.0/ 3/  .85       29.8/ 3/  .49       43.5/ 3/  .74       29.5/ 3/  .49
   CO2 BCKGRD METER/RANGE/PCT               2.4/ 3/  .04        2.3/ 3/  .04        2.2/ 3/  .03        1.9/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM              44.6/ 2/  45.       17.7/ 2/  18.       42.2/ 2/  42.       17.0/ 2/  17.
   NOX BCKGRD METER/RANGE/PPM                .2/ 2/   0.         .3/ 2/   0.         .3/ 2/   0.         .5/ 2/   1.
   DILUTION FACTOR                            13.19               23.24               15.38               23.50
   HC  CONCENTRATION PPM                      68.                  2.                  5.                  1.
   CO  CONCENTRATION PPM                     225.                 50.                 84.                 50.
   CO2 CONCENTRATION PCT                      .81                 .46                 .71                 .46
   NOX CONCENTRATION PPM                     44.4                17.4                41.9                16.5
   HC  MASS GRAMS                             6.88                 .27                 .50                 .25
   CO  MASS GRAMS                            19.88                7.62                7.39                7.57
   CO2 MASS GRAMS                           1132.3              1098.8               989.8              1097.7
   NOX MASS GRAMS                             6.59                4.45                6.22                4.22

   HC  GRAMS/KM                               1.20                 .04                 .09                 .04
   CO  GRAMS/KM                               3.45                1.23                1.27                1.21
   CO2 GRAMS/KM                              196.5               177.6               170.4               175.5
   NOX GRAMS/KM                               1.14                 .72                1.07                 .67
   FUEL CONSUMPTION BY CB L/100KM            18.72               16.51               15.87               16.31

   RUN TIME             SECONDS              504.                868.                504.                868.
   MEASURED DISTANCE    KM                   5.76                6.19                5.81                6.25
   SCF, DRY                                  .961       .965     .968                .963       .966     .968
         DFC, WET (DRY)                             .945( .924)                             .949( .928)
         TOT VOL (SCM) / SAM BLR (SCM)             206.9/  0.00                            206.6/  0.00
         KM  (MEASURED)                               11.95                                   12.06
         FUEL CONSUMPTION L/100KM                     17.58                                   16.10

COMPOSITE RESULTS                                                                     3-BAG       (4-BAG)
   TEST NUMBER          891                          CARBON DIOXIDE        G/KM       179.6      ( 178.9)
   BAROMETER    MM HG  745.7                         FUEL CONSUMPTION      L/100KM    16.79      ( 16.73)
   HUMIDITY     G/KG    11.4                         HYDROCARBONS (THC)    G/KM         .29      (   .29)
   TEMPERATURE  DEG C   21.7                         CARBON MONOXIDE       G/KM        1.70      (  1.70)
                                                     OXIDES OF NITROGEN    G/KM         .90      (   .89)
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                                        HFET  - VEHICLE EMISSIONS RESULTS -METHANOL
                                                PROJECT 05-6619-001

TEST NO.   891       RUN   1                 VEHICLE NO.84                   TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 VW RABBIT                 DATE    1/28/82                 ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                   BAG CART NO.  1                 GASOLINE  EM-464-F
TRANSMISSION A3                              DYNO NO.      3                 ODOMETER  3781. KM( 2349. MILES)
                                             CVS NO.   2

BAROMETER 746.25 MM HG(29.38 IN HG)          DRY BULB TEMP. 25.0 DEG C(77.0 DEG F)
RELATIVE HUMIDITY  52. PCT                   ABS. HUMIDITY 10.6 GM/KG        NOX HUMIDITY CORRECTION FACTOR  1.00
BAG RESULTS
   TEST CYCLE                                    HFET

   BLOWER DIF P MM. H2O(IN. H2O)           800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)         792.5 (31.2)
   BLOWER INLET TEMP. DEG. C(DEG. F)        43.3 (110.0)
   BLOWER REVOLUTIONS                         61190.
   TOT FLOW STD. CU. METRES(SCF)           116.6 ( 4116.)
   HC  SAMPLE METER/RANGE/PPM              10.7/ 2/  11.
   HC  BCKGRD METER/RANGE/PPM               7.5/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM              87.8/13/  88.
   CO  BCKGRD METER/RANGE/PPM               1.5/13/   1.
   CO2 SAMPLE METER/RANGE/PCT              64.3/ 3/ 1.15
   CO2 BCKGRD METER/RANGE/PCT               1.8/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM              62.8/ 2/  63.
   NOX BCKGRD METER/RANGE/PPM                .8/ 2/   1.
   DILUTION FACTOR                            10.00
   HC  CONCENTRATION PPM                       4.
   CO  CONCENTRATION PPM                      82.
   CO2 CONCENTRATION PCT                      1.12
   NOX CONCENTRATION PPM                      62.1
   HC  MASS GRAMS                              .61
   CO  MASS GRAMS                            11.16
   CO2 MASS GRAMS                           2399.2
   NOX MASS GRAMS                            13.79
   RUN TIME             SECONDS               765.
        DFC, WET (DRY)                     .900 ( .885)
        SCF, WET (DRY)                    1.000 ( .960)
        VOL (SCM)                            116.6
        SAM BLR (SCM)                         0.00
        KM  (MEASURED)                       16.15

   TEST NUMBER,                             891
   BAROMETER,           MM HG                746.3
   HUMIDITY,            G/KG                  10.6
   TEMPERATURE,         DEG C                 25.0
   CARBON DIOXIDE,      G/KM                 148.5
   FUEL CONSUMPTION,    L/100KM               13.76

   HYDROCARBONS,        G/KM                   .04
   CARBON MONOXIDE,     G/KM                   .69
   OXIDES OF NITROGEN,  G/KM                   .85
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TABLE D-25. TEST NO. 892 EMISSIONS RESULTS

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                                          TP   - VEHICLE EMISSIONS RESULTS -METHANOL
                                                 ROJECT 05-6619-003

TEST NO.   892      RUN   1                        VEHICLE NO.84                      TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL    81 VW RABBIT                      DATE     1/29/82                   ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                         BAG CART NO. 1 / CVS NO.  2        GASOLINE  EM-464-F
TRANSMISSION A3                                    DYNO NO.      3                    ODOMETER  3799. KM( 2360. MILES)

BAROMETER 739.90 MM HG(29.13 IN HG)                DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  63. PCT                         ABS. HUMIDITY 12.4 GM/KG           NOX HUMIDITY CORRECTION FACTOR  1.06
BAG RESULTS
   BAG NUMBER                                      1                  2                  3                  4
   DESCRIPTION                              COLD TRANSIENT        STABILIZED        HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)            787.4 (31.0)       787.4 (31.0)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET P MM. H2O(IN. H2O)          787.4 (31.0)       787.4 (31.0)       784.9 (30.9)       784.9 (30.9)
   BLOWER INLET TEMP. DEG. C(DEG. F)         43.3 (110.0)       42.8 (109.0)       43.3 (110.0)       42.8 (109.0)
   BLOWER REVOLUTIONS                          40479.             69556.             40456.             69512.
   TOT FLOW STD. CU. METRES(SCF)             75.4 ( 2662.)     129.6 ( 4578.)      75.4 ( 2661.)     129.6 ( 4576.)
   HC  SAMPLE METER/RANGE/PPM               90.4/ 2/  90.      13.2/ 2/  13.      12.9/ 2/  13.      10.1/ 2/  10.
   HC  BCKGRD METER/RANGE/PPM               11.1/ 2/  11.      13.0/ 2/  13.      10.1/ 2/  10.       9.5/ 2/  10.
   CO  SAMPLE METER/RANGE/PPM               95.9/12/ 241.      57.9/13/  55.      93.1/13/  94.      62.9/13/  61.
   CO  BCKGRD METER/RANGE/PPM                3.3/12/   6.       4.4/13/   4.        .1/13/   0.        .1/13/   0.
   CO2 SAMPLE METER/RANGE/PCT               51.0/ 3/  .89      30.9/ 3/  .51      43.9/ 3/  .75      30.0/ 3/  .50
   CO2 BCKGRD METER/RANGE/PCT                2.7/ 3/  .04       2.2/ 3/  .03       2.7/ 3/  .04       2.3/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               48.7/ 2/  49.      18.2/ 2/  18.      45.5/ 2/  46.      17.6/ 2/  18.
   NOX BCKGRD METER/RANGE/PPM                 .4/ 2/   0.        .4/ 2/   0.        .3/ 2/   0.        .2/ 2/   0.
   DILUTION FACTOR                               12.61              22.34              15.21              23.04
   HC  CONCENTRATION PPM                         80.                 1.                 3.                 1.
   CO  CONCENTRATION PPM                        225.                50.                90.                58.
   CO2 CONCENTRATION PCT                         .85                .48                .71                .46
   NOX CONCENTRATION PPM                        48.3               17.8               45.2               17.4
   HC  MASS GRAMS                               8.05                .14                .35                .17
   CO  MASS GRAMS                              19.70               7.49               7.89               8.80
   CO2 MASS GRAMS                             1170.9             1138.5              982.6             1096.4
   NOX MASS GRAMS                               7.39               4.68               6.91               4.57

   HC  GRAMS/KM                                 1.38                .02                .06                .03
   CO  GRAMS/KM                                 3.37               1.20               1.37               1.42
   CO2 GRAMS/KM                                200.3              182.1              170.6              177.5
   NOX GRAMS/KM                                 1.26                .75               1.20                .74
   FUEL CONSUMPTION BY CB L/100KM              19.08              16.92              15.89              16.53

   RUN TIME              SECONDS                504.               868.               505.               868.
   MEASURED DISTANCE     KM                     5.84               6.25               5.76               6.18
   SCF, DRY                                     .962       .967     .969               .965       .968     .970
        DFC, WET (DRY)                                .943( .923)                           .948( .929)
        TOT VOL (SCM) / SAM BLR (SCM)                205.0/  0.00                          205.0/  0.00
        KM  (MEASURED)                                   12.10                                 11.94
        FUEL CONSUMPTION L/100KM                         17.96                                 16.22

COMPOSITE RESULTS                                                                              3-BAG      (4-BAG)
   TEST NUMBER          892                                      CARBON DIOXIDE      G/KM      182.7      ( 181.4)
   BAROMETER    MM HG  739.9                                     FUEL CONSUMPTION    L/100KM   17.09      ( 16.97)
   HUMIDITY     G/KG    12.4                                     HYDROCARBONS (THC)  G/KM        .31      (   .32)
   TEMPERATURE  DEG C   24.4                                     CARBON MONOXIDE     G/KM       1.70      (  1.76)
                                                                 OXIDES OF NITROGEN  G/KM        .98      (   .98)
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                                          HFET  - VEHICLE EMISSIONS RESULTS -METHANOL
                                                  PROJECT 05-6619-003

TEST NO.   892      RUN   1                        VEHICLE NO.84                      TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL    81 VW RABBIT                      DATE     1/29/82                   ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4                         BAG CART NO.  1                    GASOLINE  EM-464-F
TRANSMISSION A3                                    DYNO NO.      3                    ODOMETER  3823. KM( 2375. MILES)
                                                   CVS NO.   2

BAROMETER 739.39 MM HG(29.11 IN HG)                DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  44. PCT                         ABS. HUMIDITY  8.5 GM/KG           NOX HUMIDITY CORRECTION FACTOR   .93
BAG RESULTS
   TEST CYCLE                                      HFET

   BLOWER DIF P MM. H2O(IN. H2O)            800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)          800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)         42.8 (109.0)
   BLOWER REVOLUTIONS                          61267.
   TOT FLOW STD. CU. METRES(SCF)            115.7 ( 4085.)
   HC  SAMPLE METER/RANGE/PPM               29.4/ 2/  29.
   HC  BCKGRD METER/RANGE/PPM               27.9/ 2/  28.
   CO  SAMPLE METER/RANGE/PPM               56.2/12/ 122.
   CO  BCKGRD METER/RANGE/PPM                 .1/12/   0.
   CO2 SAMPLE METER/RANGE/PCT               67.5/ 3/ 1.21
   CO2 BCKGRD METER/RANGE/PCT                2.4/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM               80.6/ 2/  81.
   NOX BCKGRD METER/RANGE/PPM                 .4/ 2/   0.
   DILUTION FACTOR                               9.43
   HC  CONCENTRATION PPM                         4.
   CO  CONCENTRATION PPM                       115.
   CO2 CONCENTRATION PCT                        1.18
   NOX CONCENTRATION PPM                       80.2
   HC  MASS GRAMS                                .69
   CO  MASS GRAMS                              15.52
   CO2 MASS GRAMS                            2500.4
   NOX MASS GRAMS                              16.52
   RUN TIME              SECONDS              765.
        DFC, WET (DRY)                      .894 ( .881)
        SCF, WET (DRY)                     1.000 ( .961)
        VOL (SCM)                            115.7
        SAM BLR (SCM)                          0.00
        KM  (MEASURED)                        16.49

   TEST NUMBER,                              892
   BAROMETER,            MM HG               739.4
   HUMIDITY,             G/KG                  8.5
   TEMPERATURE,          DEG C                23.9
   CARBON DIOXIDE,       G/KM                151.6
   FUEL CONSUMPTION,     L/100KM              14.08

   HYDROCARBONS,         G/KM                   .04
   CARBON MONOXIDE,      G/KM                   .94
   OXIDES OF NITROGEN,   G/KM                  1.00
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TABLE D-26. TEST NO. 901 EMISSIONS RESULTS

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                                      TP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                               PROJECT 05-6619-003

TEST NO.   901       RUN   1                             VEHICLE NO.88                             TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                           DATE     2/ 1/82                          ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                               BAG CART NO. 1 / CVS NO.  2               GASOLINE  EM-464-F
TRANSMISSION A3                                          DYNO NO.       3                          ODOMETER 11330. KM( 7040. MILES)

BAROMETER 746.51 MM HG(29.39 IN HG)                      DRY BULB TEMP. 23.3 DEG C(74.0 DEG F)
RELATIVE HUMIDITY  24. PCT                               ABS. HUMIDITY  4.3 GM/KG                  NOX HUMIDITY CORRECTION FACTOR   .83
BAG RESULTS
   BAG NUMBER                                                 1                    2                      3                     4
   DESCRIPTION                                          COLD TRANSIENT        STABILIZED           HOT TRANSIENT          STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)                         789.9 (31.1)         789.9 (31.1)         787.4 (31.0)          787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)                       789.9 (31.1)         789.9 (31.1)         787.4 (31.0)          787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)                      43.3 (110.0)         42.2 (108.0)         42.8 (109.0)          42.8 (109.0)
   BLOWER REVOLUTIONS                                       40470.              69515.               40422.                69448.
   TOT FLOW STD. CU. METRES(SCF)                          76.1 ( 2686.)       130.9 ( 4623.)        76.1 ( 2687.)        130.7 ( 4616.)
   HC  SAMPLE METER/RANGE/PPM                            55.9/ 2/  56.        11.6/ 2/  12.        20.7/ 2/  21.         10.3/ 2/  10.
   HC  BCKGRD METER/RANGE/PPM                             9.4/ 2/   9.         8.9/ 2/   9.         8.3/ 2/   8.          7.9/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM                            68.6/11/ 286.        11.8/13/  11.        50.0/12/ 106.          9.6/13/   9.
   CO  BCKGRD METER/RANGE/PPM                             1.3/11/   4.         3.9/13/   4.         1.4/12/   3.          2.3/13/   2.
   CO2 SAMPLE METER/RANGE/PCT                            52.6/ 3/  .92        33.6/ 3/  .56        43.8/ 3/  .75         32.4/ 3/  .54
   CO2 BCKGRD METER/RANGE/PCT                             3.0/ 3/  .05         3.1/ 3/  .05         2.7/ 3/  .04          2.4/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                            26.3/ 2/  26.         4.8/ 2/   5.         9.9/ 2/  10.          4.9/ 2/   5.
   NOX BCKGRD METER/RANGE/PPM                              .4/ 2/   0.          .4/ 2/   0.          .4/ 2/   0.           .5/ 2/   1.
   DILUTION FACTOR                                          12.18                20.59                15.21                 21.42
   HC  CONCENTRATION PPM                                    47.                   3.                  13.                    3.
   CO  CONCENTRATION PPM                                   273.                   7.                 100.                    7.
   CO2 CONCENTRATION PCT                                    .88                  .52                  .71                   .50
   NOX CONCENTRATION PPM                                   25.9                  4.4                  9.5                   4.4
   HC  MASS GRAMS                                          4.79                  .55                 1.31                   .48
   CO  MASS GRAMS                                         24.14                 1.08                 8.88                   .99
   CO2 MASS GRAMS                                        1219.2               1234.9                989.5                1205.5
   NOX MASS GRAMS                                          3.12                  .91                 1.15                   .91

   HC  GRAMS/KM                                             .83                  .09                  .23                   .08
   CO  GRAMS/KM                                            4.19                  .17                 1.53                   .16
   CO2 GRAMS/KM                                           211.5                196.3                170.4                 192.4
   NOX GRAMS/KM                                             .54                  .15                  .20                   .15
   FUEL CONSUMPTION BY CB L/100KM                         20.16                18.08                15.92                 17.72

   RUN TIME              SECONDS                          504.                 867.                 505.                  867.
   MEASURED DISTANCE     KM                               5.76                 6.29                 5.81                  6.27
   SCF, DRY                                               .974        .978     .981                 .977        .980      .981
         DFC, WET (DRY)                                          .939( .932)                               .946( .939)
         TOT VOL (SCM) / SAM BLR (SCM)                          207.0/  0.00                              206.8/  0.00
         KM  (MEASURED)                                            12.05                                     12.07
         FUEL CONSUMPTION L/100KM                                  19.08                                     16.85

COMPOSITE RESULTS                                                                                          3-BAG       (4-BAG)
   TEST NUMBER          901                                              CARBON DIOXIDE       G/KM        192.3      ( 191.2)
   BAROMETER    MM HG  746.5                                             FUEL CONSUMPTION     L/100KM     17.92      ( 17.81)
   HUMIDITY     G/KG     4.3                                             HYDROCARBONS (THC)   G/KM          .28      (   .28)
   TEMPERATURE  DEG C   23.3                                             CARBON MONOXIDE      G/KM         1.37      (  1.37)
                                                                         OXIDES OF NITROGEN   G/KM          .24      (   .24)
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                                      HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-6619-003

TEST NO.   901       RUN   1                             VEHICLE NO.88                             TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                           DATE     2/ 1/82                          ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                               BAG CART NO.  1                           GASOLINE  EM-464-F
TRANSMISSION A3                                          DYNO NO.       3                          ODOMETER 11355. KM( 7056. MILES)
                                                         CVS NO.   2

BAROMETER 745.49 MM HG(29.35 IN HG)                      DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  25. PCT                               ABS. HUMIDITY  4.7 GM/KG                  NOX HUMIDITY CORRECTION FACTOR   .83
BAG RESULTS
   TEST CYCLE                                              HFET

   BLOWER DIF P MM. H2O(IN. H2O)                         800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)                       800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)                      42.8 (109.0)
   BLOWER REVOLUTIONS                                       61257.
   TOT FLOW STD. CU. METRES(SCF)                         114.1 ( 4028.)
   HC  SAMPLE METER/RANGE/PPM                            14.4/ 2/  14.
   HC  BCKGRD METER/RANGE/PPM                             7.6/ 2/   8.
   CO  SAMPLE METER/RANGE/PPM                            39.9/13/  37.
   CO  BCKGRD METER/RANGE/PPM                             1.8/13/   2.
   CO2 SAMPLE METER/RANGE/PCT                            60.9/ 3/ 1.08
   CO2 BCKGRD METER/RANGE/PCT                             2.1/ 3/  .03
   NOX SAMPLE METER/RANGE/PPM                            15.4/ 2/  15.
   NOX BCKGRD METER/RANGE/PPM                              .6/ 2/   1.
   DILUTION FACTOR                                          10.66
   HC  CONCENTRATION PPM                                     8.
   CO  CONCENTRATION PPM                                    34.
   CO2 CONCENTRATION PCT                                    1.05
   NOX CONCENTRATION PPM                                    14.9
   HC  MASS GRAMS                                           1.14
   CO  MASS GRAMS                                           4.54
   CO2 MASS GRAMS                                         2196.6
   NOX MASS GRAMS                                           2.70
   RUN TIME              SECONDS                           766.
         DFC, WET (DRY)                                  .906 ( .899)
         SCF, WET (DRY)                                 1.000 ( .970)
         VOL (SCM)                                         114.1
         SAM BLR (SCM)                                      0.00
         KM  (MEASURED)                                    16.53

   TEST NUMBER,                                           901
   BAROMETER,            MM HG                            745.5
   HUMIDITY,             G/KG                               4.7
   TEMPERATURE,          DEG C                             23.9
   CARBON DIOXIDE,       G/KM                             132.9
   FUEL CONSUMPTION,     L/100KM                           12.26

   HYDROCARBONS,         G/KM                               .07
   CARBON MONOXIDE,      G/KM                               .27
   OXIDES OF NITROGEN,   G/KM                               .16
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TABLE D-27. TEST NO. 902 EMISSIONS RESULTS

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                                        FTP   - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-6619-003

TEST NO.   902      RUN   1                    VEHICLE NO.88                          TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                 DATE    2/ 2/82                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                     BAG CART NO. 1 / CVS NO.  2            GASOLINE  EM-464-F
TRANSMISSION A3                                DYNO NO.      3                        ODOMETER 11376. KM( 7069. MILES)

BAROMETER 740.92 MM HG(29.17 IN HG)            DRY BULB TEMP. 23.3 DEG C(74.0 DEG F)
RELATIVE HUMIDITY  40. PCT                     ABS. HUMIDITY  7.4 GM/KG               NOX HUMIDITY CORRECTION FACTOR   .90
BAG RESULTS
   BAG NUMBER                                         1                 2                  3                  4
   DESCRIPTION                                 COLD TRANSIENT      STABILIZED        HOT TRANSIENT        STABILIZED

   BLOWER DIF P MM. H2O(IN. H2O)               787.4 (31.0)       787.4 (31.0)      787.4 (31.0)       787.4 (31.0)
   BLOWER INLET P MM. H2O(IN. H2O)             787.4 (31.0)       787.4 (31.0)      787.4 (31.0)       787.4 (31.0)
   BLOWER INLET TEMP. DEG. C(DEG. F)            42.8 (109.0)       42.8 (109.0)      42.8 (109.0)       42.8 (109.0)
   BLOWER REVOLUTIONS                            40322.             69444.            40364.             69455.
   TOT FLOW STD. CU. METRES(SCF)                75.3 ( 2658.)     129.6 ( 4578.)     75.4 ( 2661.)     129.7 ( 4578.)
   HC  SAMPLE METER/RANGE/PPM                 67.2/ 2/  67.      12.7/ 2/  13.     22.7/ 2/  23.      11.7/ 2/  12.
   HC  BCKGRD METER/RANGE/PPM                 11.3/ 2/  11.      11.1/ 2/  11.     11.0/ 2/  11.      10.3/ 2/  10.
   CO  SAMPLE METER/RANGE/PPM                 67.8/11/ 281.       9.6/13/   9.     59.0/12/ 129.       9.6/13/   9.
   CO  BCKGRD METER/RANGE/PPM                   .6/11/   2.       1.9/13/   2.       .7/12/   1.       1.5/13/   1.
   CO2 SAMPLE METER/RANGE/PCT                 52.3/ 3/  .91      33.6/ 3/  .56     44.6/ 3/  .76      33.0/ 3/  .55
   CO2 BCKGRD METER/RANGE/PCT                  2.7/ 3/  .04       2.4/ 3/  .04      2.6/ 3/  .04       2.3/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                 28.7/ 2/  29.       3.9/ 2/   4.     10.0/ 2/  10.       3.9/ 2/   4.
   NOX BCKGRD METER/RANGE/PPM                   .3/ 2/   0.        .3/ 2/   0.       .2/ 2/   0.        .2/ 2/   0.
   DILUTION FACTOR                               12.25              20.59             14.87              21.00
   HC  CONCENTRATION PPM                          57.                 2.               12.                 2.
   CO  CONCENTRATION PPM                         268.                 7.              123.                 7.
   CO2 CONCENTRATION PCT                           .87               .53               .73                .52
   NOX CONCENTRATION PPM                         28.4                3.6               9.8                3.7
   HC  MASS GRAMS                                 5.70               .37              1.25                .33
   CO  MASS GRAMS                                23.51              1.03             10.80               1.08
   CO2 MASS GRAMS                              1204.1             1247.1            1002.9             1225.0
   NOX MASS GRAMS                                 3.69               .81              1.27                .83

   HC  GRAMS/KM                                   1.00               .06               .22                .05
   CO  GRAMS/KM                                   4.13               .17              1.89                .18
   CO2 GRAMS/KM                                 211.7              203.1             175.7              199.6
   NOX GRAMS/KM                                    .65               .13               .22                .14
   FUEL CONSUMPTION BY CB L/100KM                20.19             18.70             16.45              18.38

   RUN TIME            SECONDS                   504.              868.              504.               868.
   MEASURED DISTANCE   KM                        5.69              6.14              5.71               6.14
   SCF, DRY                                      .969      .973     .976              .972      .974     .976
        DFC, WET (DRY)                                 .939( .927)                           .945( .933)
        TOT VOL (SCM) / SAM BLR (SCM)                 204.9/  0.00                          205.0/  0.00
        KM  (MEASURED)                                   11.83                                 11.85
        FUEL CONSUMPTION L/100KM                         19.42                                 17.45

COMPOSITE RESULTS                                                                                  3-BAG     (4-BAG)
   TEST NUMBER          902                                  CARBON DIOXIDE       G/KM          197.3     ( 196.3)
   BAROMETER    MM HG  740.9                                 FUEL CONSUMPTION     L/100KM       18.39     ( 18.30)
   HUMIDITY     G/KG     7.4                                 HYDROCARBONS (THC)   G/KM            .30     (   .30)
   TEMPERATURE  DEG C   23.3                                 CARBON MONOXIDE      G/KM           1.46     (  1.46)
                                                             OXIDES OF NITROGEN   G/KM            .26     (   .26)
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                                        HFET  - VEHICLE EMISSIONS RESULTS -METHANOL FUEL
                                                PROJECT 05-6619-003

TEST NO.   902      RUN   1                    VEHICLE NO.88                          TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT                 DATE    2/ 2/82                        ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4                     BAG CART NO.  1                        GASOLINE  EM-464-F
TRANSMISSION A3                                DYNO NO.      3                        ODOMETER 11401. KM( 7084. MILES)
                                               CVS NO.   2

BAROMETER 740.41 MM HG(29.15 IN HG)            DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  29. PCT                     ABS. HUMIDITY  5.7 GM/KG               NOX HUMIDITY CORRECTION FACTOR   .86
BAG RESULTS
   TEST CYCLE                                      HFET

   BLOWER DIF P MM. H2O(IN. H2O)               800.1 (31.5)
   BLOWER INLET P MM. H2O(IN. H2O)             800.1 (31.5)
   BLOWER INLET TEMP. DEG. C(DEG. F)            42.8 (109.0)
   BLOWER REVOLUTIONS                            61202.
   TOT FLOW STD. CU. METRES(SCF)               113.1 ( 3994.)
   HC  SAMPLE METER/RANGE/PPM                 15.6/ 2/  16.
   HC  BCKGRD METER/RANGE/PPM                  9.6/ 2/  10.
   CO  SAMPLE METER/RANGE/PPM                 35.9/13/  33.
   CO  BCKGRD METER/RANGE/PPM                  1.2/13/   1.
   CO2 SAMPLE METER/RANGE/PCT                 63.0/ 3/ 1.12
   CO2 BCKGRD METER/RANGE/PCT                  2.4/ 3/  .04
   NOX SAMPLE METER/RANGE/PPM                 18.7/ 2/  19.
   NOX BCKGRD METER/RANGE/PPM                   .2/ 2/   0.
   DILUTION FACTOR                               10.27
   HC  CONCENTRATION PPM                           7.
   CO  CONCENTRATION PPM                          31.
   CO2 CONCENTRATION PCT                          1.09
   NOX CONCENTRATION PPM                         18.5
   HC  MASS GRAMS                                 1.04
   CO  MASS GRAMS                                 4.06
   CO2 MASS GRAMS                              2256.4
   NOX MASS GRAMS                                 3.44
   RUN TIME                SECONDS              765.
        DFC, WET (DRY)                         .903 ( .894)
        SCF, WET (DRY)                        1.000 ( .968)
        VOL (SCM)                               113.1
        SAM BLR (SCM)                             0.00
        KM  (MEASURED)                           16.33

   TEST NUMBER,                                 902
   BAROMETER,            MM HG                  740.4
   HUMIDITY,             G/KG                     5.7
   TEMPERATURE,          DEG C                   24.4
   CARBON DIOXIDE,       G/KM                   138.2
   FUEL CONSUMPTION,     L/100KM                 12.75

   HYDROCARBONS,         G/KM                      .06
   CARBON MONOXIDE,      G/KM                      .25
   OXIDES OF NITROGEN,   G/KM                      .21
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APPENDIX E

TABLE E-1 FORD ESCORT EMISSIONS WITH METHANOL-ISOPENTANE BLEND
TABLE E-2 VW RABBIT EMISSIONS WITHOUT CATALYST

TABLE E-1. FORD ESCORT EMISSIONS WITH METHANOL-ISOPENTANE BLEND

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                                         FTP  - VEHICLE EMISSIONS RESULTS -METHANOL +ISOPENTANE
                                                PROJECT 05-5830-011

TEST NO.   5.5PEN   RUN   1              VEHICLE NO.82                         TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL   81 FORD ESCORT           DATE   11/30/81                       ACTUAL ROAD LOAD   5.3 KW(  7.1 HP)
ENGINE 1.6 L( 98. CID) L-4               BAG CART NO.  1                       GASOLINE  METHANOL
TRANSMISSION A3                          DYNO NO.      3                       ODOMETER  9815. KM( 6099. MILES)
                                         CVS NO.   2

BAROMETER 733.81 MM HG(28.89 IN HG)      DRY BULB TEMP. 24.4 DEG C(76.0 DEG F)
RELATIVE HUMIDITY  26. PCT               ABS. HUMIDITY  5.2 GM/KG              NOX HUMIDITY CORRECTION FACTOR   .85
BAG RESULTS
  BAG NUMBER                                    1                 2                  3
  DESCRIPTION                            COLD TRANSIENT      STABILIZED        HOT TRANSIENT        STABILIZED

  BLOWER DIF P MM. H2O(IN. H2O)           784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
  BLOWER INLET P MM. H2O(IN. H2O)         784.9 (30.9)       784.9 (30.9)       784.9 (30.9)
  BLOWER INLET TEMP. DEG. C(DEG. F)        43.3 (110.0)       42.8 (109.0)       42.8 (109.0)
  BLOWER REVOLUTIONS                        40537.             69613.             40453.
  TOT FLOW STD. CU. METRES(SCF)            74.3 ( 2623.)     127.7 ( 4508.)      74.2 ( 2619.)
  HC  SAMPLE METER/RANGE/PPM              91.7/ 2/  92.      20.7/ 2/  21.      30.5/ 2/  31.
  HC  BCKGRD METER/RANGE/PPM              16.2/ 2/  16.      12.8/ 2/  13.      11.9/ 2/  12.
  CO  SAMPLE METER/RANGE/PPM              91.6/11/ 456.      72.2/12/ 166.      95.4/12/ 240.
  CO  BCKGRD METER/RANGE/PPM               .2/11/   1.        .8/12/   1.        .7/12/   1.
  CO2 SAMPLE METER/RANGE/PCT              53.9/ 3/  .94      34.0/ 3/  .57      45.3/ 3/  .78
  CO2 BCKGRD METER/RANGE/PCT               2.4/ 3/  .04       2.5/ 3/  .04       2.7/ 3/  .04
  NOX SAMPLE METER/RANGE/PPM              26.1/ 2/  26.       3.3/ 2/   3.      11.3/ 2/  11.
  NOX BCKGRD METER/RANGE/PPM               .3/ 2/   0.        .1/ 2/   0.        .1/ 2/   0.
  DILUTION FACTOR                            11.68              19.86              14.48
  HC  CONCENTRATION PPM                      77.                 9.                19.
  CO  CONCENTRATION PPM                     439.               160.               231.
  CO2 CONCENTRATION PCT                      .91                .53                .74
  NOX CONCENTRATION PPM                     25.8                3.2               11.2
  HC  MASS GRAMS                             7.13               1.36               1.80
  CO  MASS GRAMS                            37.93              23.79              19.95
  CO2 MASS GRAMS                          1236.4             1241.7             1003.5
  NOX MASS GRAMS                             3.10                .66               1.34

  HC  GRAMS/KM                               1.24                .22                .31
  CO  GRAMS/KM                               6.59               3.82               3.47
  CO2 GRAMS/KM                             214.8              199.3              174.7
  NOX GRAMS/KM                                .54                .11                .23
  FUEL CONSUMPTION BY CB L/100KM            19.77              17.91              15.73
  RUN TIME              SECONDS             505.               868.               505.
  MEASURED DISTANCE     KM                   5.76               6.23               5.74
  SCF, DRY                                   .973               .981               .977

COMPOSITE RESULTS                                                                                     3-BAG      (4-BAG)
  TEST NUMBER             5.5PEN                             CARBON DIOXIDE        G/KM              195.8      (   0.0)
  BAROMETER      MM HG   733.8                               FUEL CONSUMPTION      L/100KM            17.70      (  0.00)
  HUMIDITY       G/KG      5.2                               HYDROCARBONS (THC)    G/KM                 .46      (  0.00)
  TEMPERATURE    DEG C    24.4                               CARBON MONOXIDE       G/KM                4.30      (  0.00)
                                                             OXIDES OF NITROGEN    G/KM                 .23      (  0.00)
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TABLE E-2. VW RABBIT EMISSIONS WITHOUT CATALYST

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                                        FTP   - VEHICLE EMISSIONS RESULTS -METHANOL W/O CAT.
                                                PROJECT 05-6619-001

TEST NO.       FTP   RUN   1            VEHICLE NO.                                  TEST WEIGHT  1134. KG( 2500. LBS)
VEHICLE MODEL    81  VW RABBIT          DATE    12/23/81                             ACTUAL ROAD LOAD   5.7 KW(  7.7 HP)
ENGINE 1.6 L( 97. CID) L-4              BAG CART NO. 1 / CVS NO.  2                  GASOLINE  EM-464-F
TRANSMISSION A3                         DYNO NO.       3                             ODOMETER  2995. KM( 1861. MILES)

BAROMETER 742.44 MM HG(29.23 IN HG)     DRY BULB TEMP. 23.9 DEG C(75.0 DEG F)
RELATIVE HUMIDITY  22. PCT              ABS. HUMIDITY  4.1 GM/KG                     NOX HUMIDITY CORRECTION FACTOR   .82
BAG RESULTS
  BAG NUMBER                                    1                   2                   3                   4
  DESCRIPTION                           COLD TRANSIENT          STABILIZED         HOT TRANSIENT        STABILIZED

  BLOWER DIF P MM. H2O(IN. H2O)          774.7 (30.5)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
  BLOWER INLET P MM. H2O(IN. H2O)        774.7 (30.5)       787.4 (31.0)       787.4 (31.0)       787.4 (31.0)
  BLOWER INLET TEMP. DEG. C(DEG. F)      42.8 (109.0)       41.7 (107.0)       42.2 (108.0)       41.7 (107.0)
  BLOWER REVOLUTIONS                      40450.             69502.             40443.             69497.
  TOT FLOW STD. CU. METRES(SCF)          75.3 ( 2658.)     129.3 ( 4567.)      75.2 ( 2655.)     129.3 ( 4567.)
  HC   SAMPLE METER/RANGE/PPM           16.9/ 3/ 169.      38.0/ 2/  38.      55.9/ 2/  56.      37.2/ 2/  37.
  HC   BCKGRD METER/RANGE/PPM             .6/ 3/   6.       6.3/ 2/   6.       6.5/ 2/   7.       6.7/ 2/   7.
  CO   SAMPLE METER/RANGE/PPM          89.2/11/ 435.      78.5/12/ 184.      67.7/11/ 281.      79.6/12/ 188.
  CO   BCKGRD METER/RANGE/PPM           1.8/11/   5.       1.7/12/   3.        .9/11/   3.       5.1/12/  10.
  CO2  SAMPLE METER/RANGE/PCT          48.0/ 3/  .83      29.7/ 3/  .49      41.1/ 3/  .70      27.6/ 3/  .45
  CO2  BCKGRD METER/RANGE/PCT           2.6/ 3/  .04       2.6/ 3/  .04       2.5/ 3/  .04       1.7/ 3/  .03
  NOX  SAMPLE METER/RANGE/PPM          71.5/ 2/  72.      28.7/ 2/  29.      65.6/ 2/  66.      28.1/ 2/  28.
  NOX  BCKGRD METER/RANGE/PPM            .1/ 2/   0.        .2/ 2/   0.        .2/ 2/   0.        .6/ 2/   1.
  DILUTION FACTOR                         13.04              22.61              15.84              24.37
  HC   CONCENTRATION PPM                 163.                32.                50.                31.
  CO   CONCENTRATION PPM                 416.               177.               270.               175.
  CO2  CONCENTRATION PCT                  .79                .45                .66                .43
  NOX  CONCENTRATION PPM                 71.4               28.5               65.4               27.5
  HC   MASS GRAMS                        16.39               5.51               4.99               5.30
  CO   MASS GRAMS                        36.45              26.71              23.66              26.32
  CO2  MASS GRAMS                       1091.4             1071.1              911.9             1014.1
  NOX  MASS GRAMS                         8.45               5.80               7.73               5.60

  HC   GRAMS/KM                           2.83                .89                .86                .86
  CO   GRAMS/KM                           6.29               4.31               4.10               4.26
  CO2  GRAMS/KM                          188.4              173.0              158.0              164.0
  NOX  GRAMS/KM                           1.46                .94               1.34                .91
  FUEL CONSUMPTION BY CB L/100KM         18.58              16.64              15.22              15.80

  RUN TIME               SECONDS         504.               867.               505.               867.
  MEASURED DISTANCE      KM               5.79               6.19               5.77               6.18
  SCF, DRY                                .976      .981      .983              .979      .982     .984
      DFC, WET (DRY)                           .944( .937)                          .951( .944)
      TOT VOL (SCM) / SAM BLR (SCM)            204.6/ 0.00                          204.5/ 0.00
      KM  (MEASURED)                              11.99                                11.96
      FUEL CONSUMPTION L/100KM                    17.58                                15.52

COMPOSITE RESULTS                                                                           3-BAG      (4-BAG)
  TEST NUMBER          880FTP                          CARBON DIOXIDE         G/KM          172.0      ( 169.4)
  BAROMETER    MM HG   742.4                           FUEL CONSUMPTION       L/100KM       16.65      ( 16.41)
  HUMIDITY     G/KG      4.1                           HYDROCARBONS (THC)     G/KM           1.29      (  1.28)
  TEMPERATURE  DEG C    23.9                           CARBON MONOXIDE        G/KM           4.67      (  4.65)
                                                       OXIDES OF NITROGEN     G/KM           1.16      (  1.15)
```

APPENDIX F

MASS SPECTRAL RESULTS

SOUTHWEST RESEARCH INSTITUTE

INTER-DEPARTMENTAL MEMORANDUM

TO: L. Smith, Div. 05

FROM: Carter Nulton, Div. 01 for C P Nulton

SUBJECT: GC/MS Analyses for 05-5830-012

May 3, 1982

Eight tenax traps were received for analysis. The samples were transferred from the traps to the head of the ambient gc column by first connecting the traps in-line with the column helium flow. The samples were then desorbed by placing the traps in a 180°C oven for four minutes.

Sample #6 (2-16-82) was lost due to a leak in the trap assembly.

Table 3 and the total ion chromatograms (Figures 1,2,3) show the similarities between the gasoline, methanol, and background tenax samples. The tenax samples contain the same compounds regardless of the sample type. This is probably due to the high level of background contamination.

Six dichloromethane extracts were received for analysis. The analysis conditions are listed in Table 2. Table 4 and the total ion chromatogram (Figures 4,5,6) show the similarities between the gasoline, methanol, and blank filters. Compounds present include cellosolves, siloxanes, and phthalates and are likely to be system contaminants. Again, the high background level prevents the interpretation of the data.

CPN:ack
Encl.

TABLE 1. SAMPLE LOG

	Sample Description	Sample type
1	Tenax Blank (2-15-82)	tenax trap
2	Sample #17 (2-15-82) gasoline engine w/o catalyst	"
3	Sample #6 (2-16-82) ABORTED	"
4	Sample #44 (2-17-82) gasoline engine with catalyst	"
5	Sample #40 (2-18-82) gasoline engine with catalyst	"
6	Sample #43 (2-19-82) methanol engine	"
7	Sample #T-842 (2-22-82) methanol engine	"
8	Method Blank - (Background)	"
9	S-191 (854) gasoline engine	extract
10	S-192 (853) gasoline engine	"
11	S-193 (843) methanol engine	"
12	S-194 (844) methanol engine	"
13	S-195 filter blank	"
14	S-196 solvent blank	"

TABLE 2. ANALYSIS CONDITIONS

	Tenax Traps	Filter Extracts
Column	1% SP1000 on 60/80 mesh Carbopack 2mm X 6 ft	DB5 capillary 30m x .248mm I.D. spitless
Carrier	He 20 mLs/min	He 1 mL/min
Program	Desorb 180°(4 min)- GC oven ambient	
initial temperature	60°C	40°C
initial hold	0 min	2 min
program rate	8°C/min	10°/min
final temperature	250°C	250°C
injection port	180°	250°
transfer line/separator	250°	250°
analyzer	100°	100°
injection size	(desorb)	2 µl
mass range	22-250 m/e	35-425 m/e
scan time	2 sec/scan	1 sec/scan

TABLE 3. COMPARISON OF TENAX SAMPLES

SCAN	Relative amounts based on external ethylbenene standard			Tentative Peak Identification
	Sample #40 gasoline (2-18-82)	Sample T-842 Methanol (2-22-82)	Method Blank (2-22-82)	
50/80	----	----	----	air & water
250	34	19	19	mixture of propane/propene
294	----	2	----	dichlorodifluoromethane
326	----	----	4	ethanol
360	1	15	2	2-methylpropane
377	0.1	----	0.5	dichloromethane
390	6	10	*	acetone
390-460	>155	16	92	saturated mixture of butane/propanol
470	0.3	1	*	cyclopentane
495	----	----	4	pentanol
530	18	27	56	2-methylbutene
540	*	3	24	trichlorotrifluoroethane
565	1	1	----	C_5H_{10}
575	20	14	26	pentane
750	4	3	19	hexane
784	0.8	0.3	----	dimethylpentane
792	0.6	0.9	7	methylcyclohexane
808	----	0.2	----	dimethylpentane
815	2	0.5	3	2,3-dimethylpentane
856	0.5	0.6	2	3-methylhexane
870	0.3	0.4	1	2-methylhexane
900	50	6	1.4	C_8H_{18}
913	7	6	2.4	toluene
950	2	0.6	1	2,4-dimethylhexane
970	1	0.3	0.4	3-ethylpentane
990	2	0.3	1	dimethylhexane
1055	9	----	0.7	trimethylhexane
1137	7	5	0.4	siloxane

*Interference

TABLE 4. COMPARISON OF FILTER EXTRACTS

SCAN NUMBER			
S-192 (853) Gasoline	S-193 (843) Methanol	S-195 Filter Blank	Tentative Peak Identification
----	----	594	ethylhexanol
----	691	696	ethyl hexanoic acid
764	765	770	butoxyethoxy ethanol
793	794	----	[[methoxyethoxy]ethoxy]ethanol
804	805	809	[ethanediylbis(oxy)bis-ethanol
857	857	----	[(ethoxyethoxy0ethoxy]ethanol
----	----	884	ethylmethyl pentamine
927	----	----	methylpyrrolidinyl pyridine
----	932	----	decanoic acid
996	----	----	dihydropyrrolylpyridine
1025	1027	----	(butoxyethoxy)ethoxyethanol
1059	1058	----	[oxybis(ethanediyloxy)]bis-ethanol
----	----	1080	biphenylol
----	1074	----	tetraoxadodecane
1102	1103	----	dodecanoic acid
1136	1136	1139	trimethylhexene
----	----	1147	tetramethylbutylphenol
1172	1173	----	phosphoric acid tributylester
1179	----	----	tetradecamethylhexasiloxane
1206	----	1210	alkane
----	----	1215	dimethyldodecane
1225	1227	----	tetradecanoic acid (methylester)
----	----	1290	alkane
1297	1299	----	hexadecamethylheptasiloxane
1337	1338	1338/mixture	phthalate
1391	1394	----	hexadecanoic acid
1400	1402	1403	phthalate
----	----	1444	unknown
----	----	1484	unknown

TABLE 4. (con't.)

SCAN NUMBER			
S-192 (853) Gasoline	S-193 (843) Methanol	S-195 Filter Blank	Tentative Peak Identification
1542	1545	1544	unknown
1654	1657	----	alkane
----	1769	----	alkane
----	----	1764	bis(ethylhexyl)ester hexanedioic acid
1844	1848	1841	unknown
2005	2006	1987	phthalate

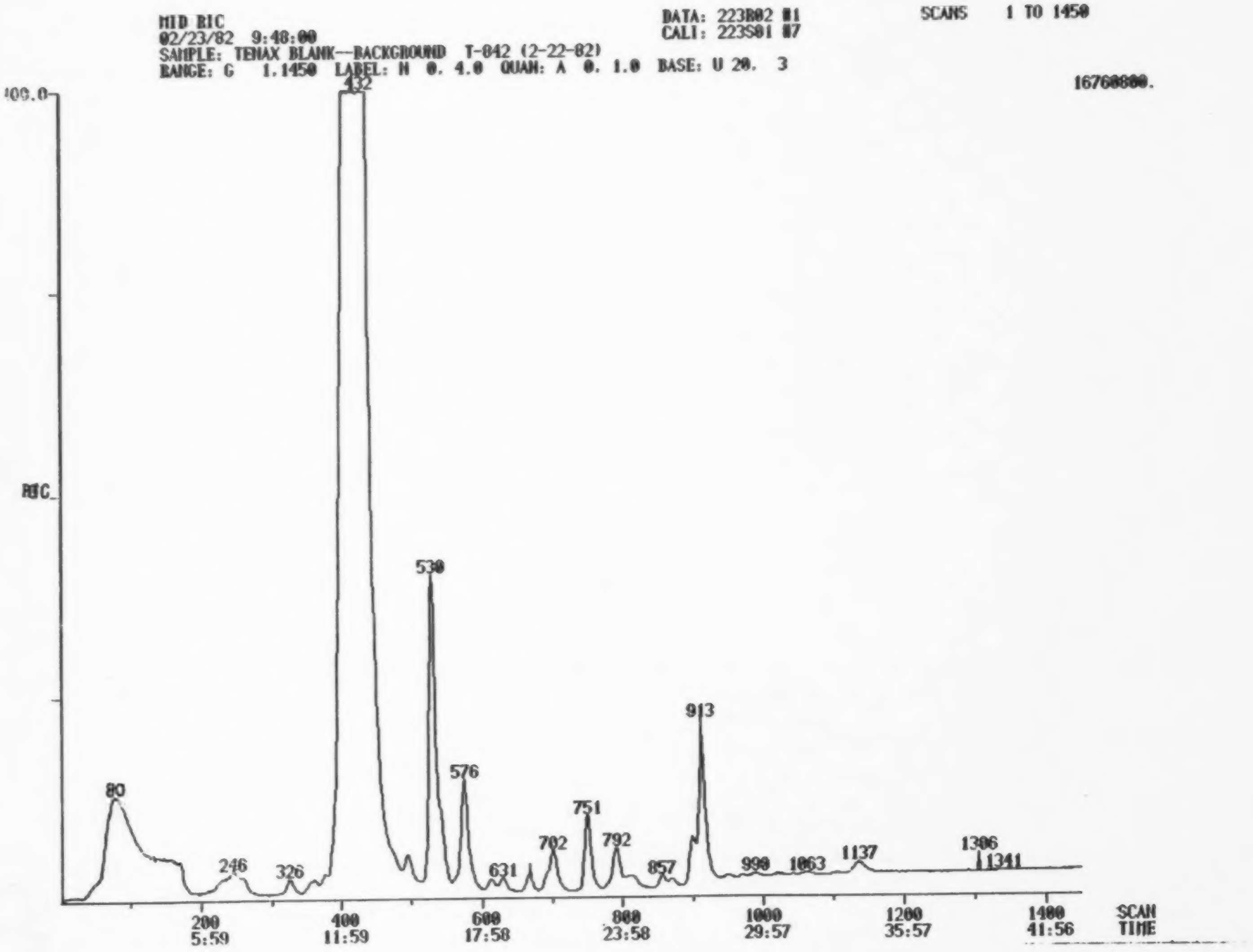

Figure 1. Total Ion Current (TIC) chromatogram of Tenax Method Blank

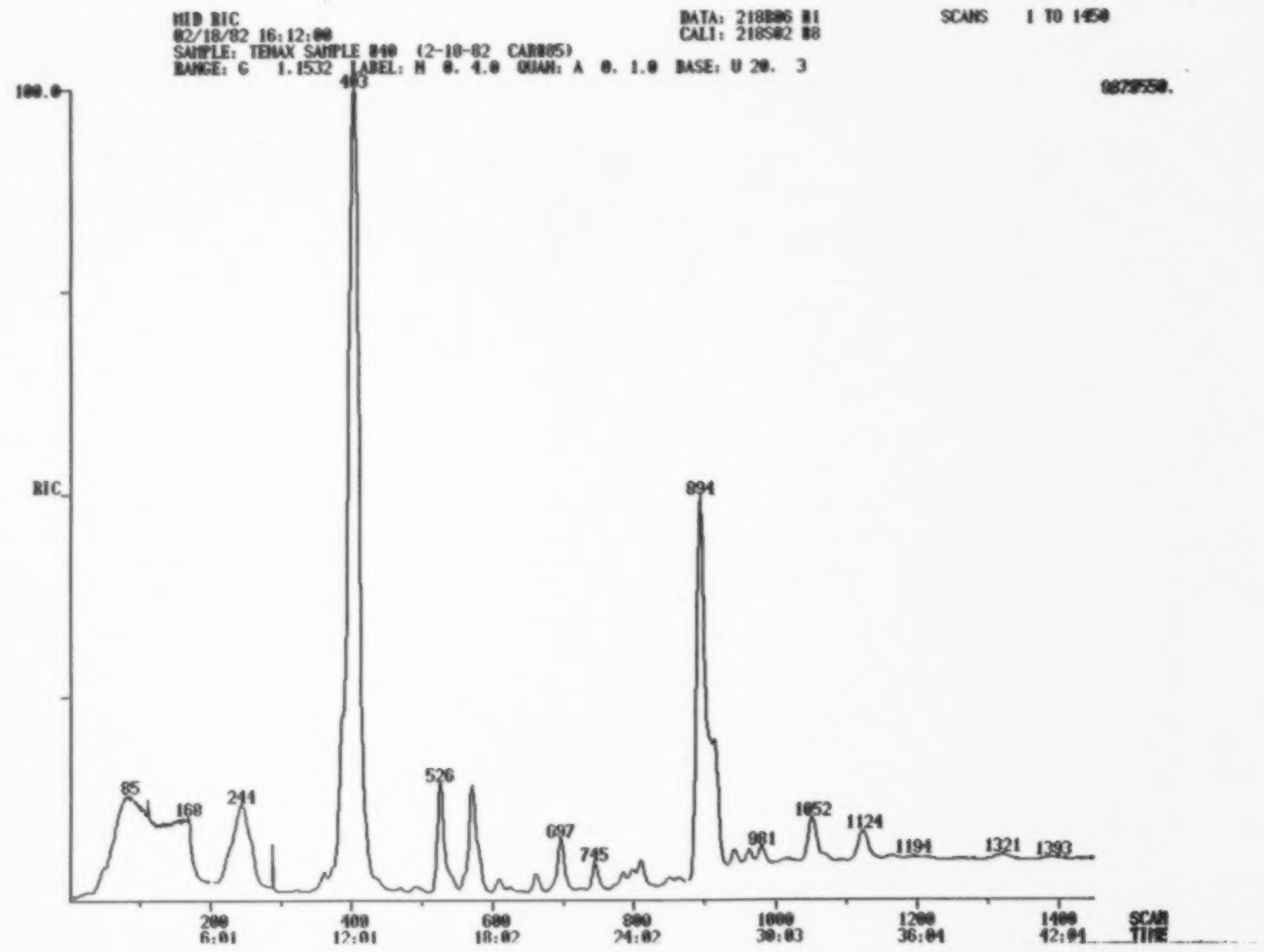

Figure 2. TIC chromatogram of Tenax sample #40 (gasoline engine)

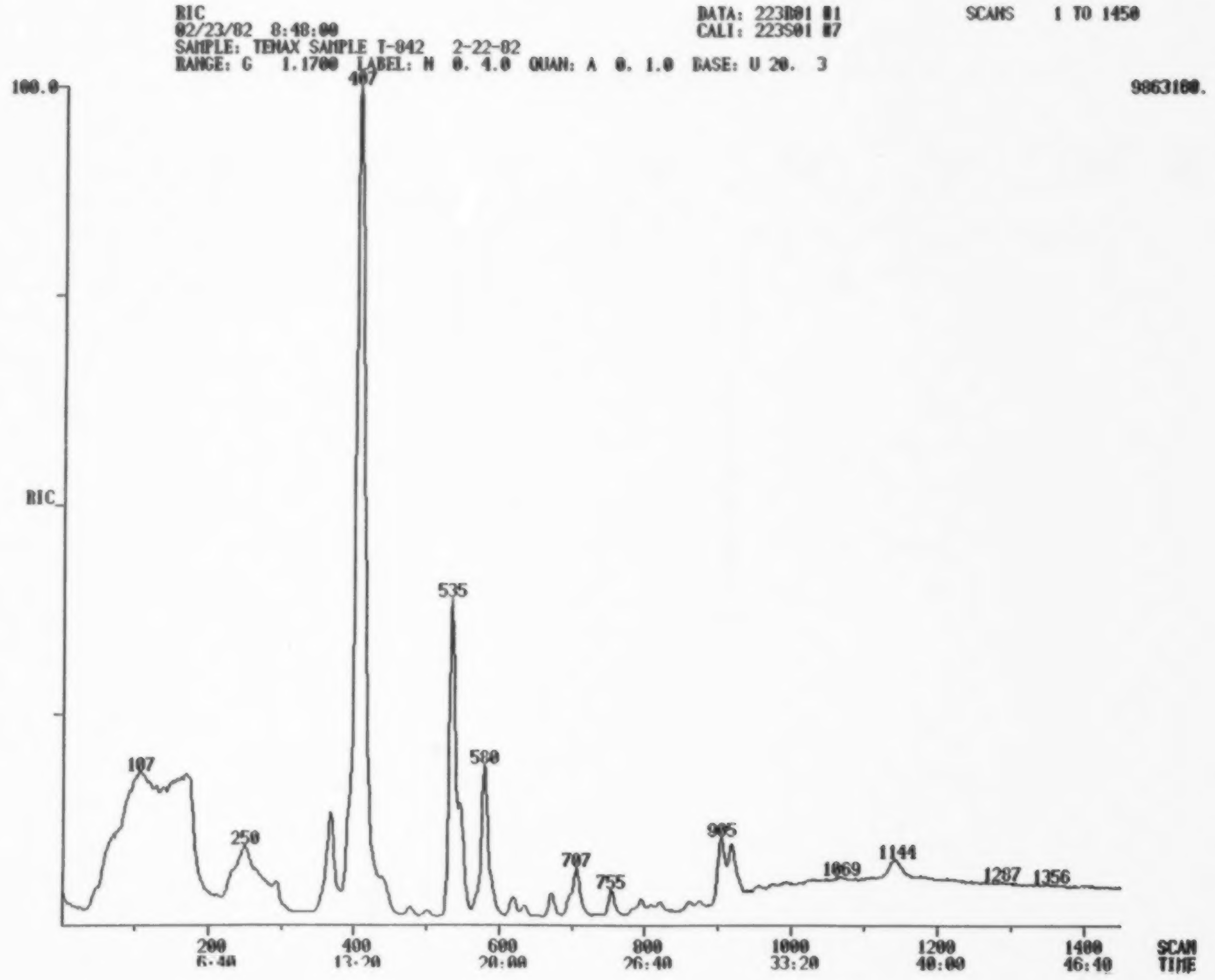

Figure 3. TIC chromatogram of Tenax sample T-842 (methanol engine)

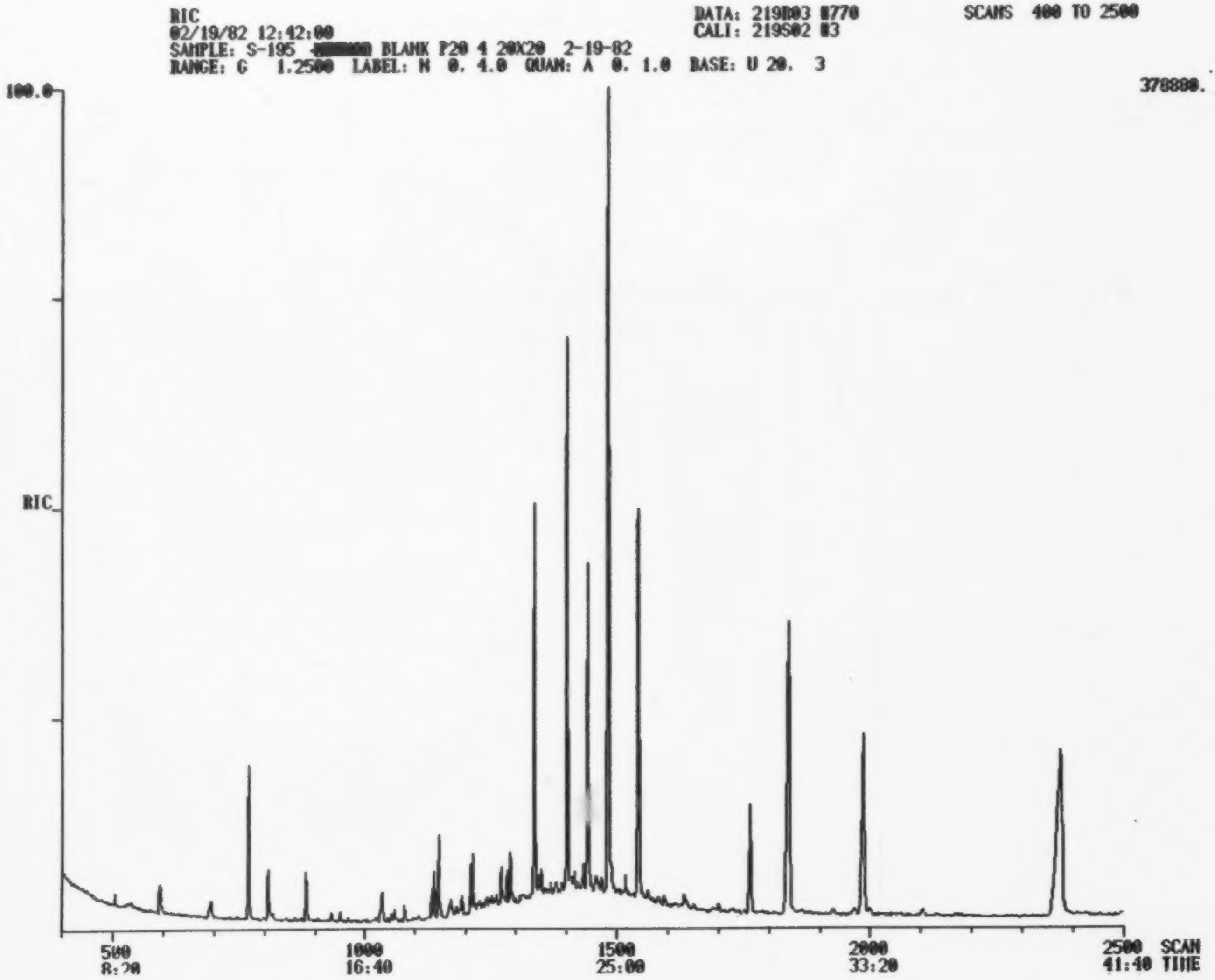

Figure 4. TIC chromatogram of extract S-195 filter blank

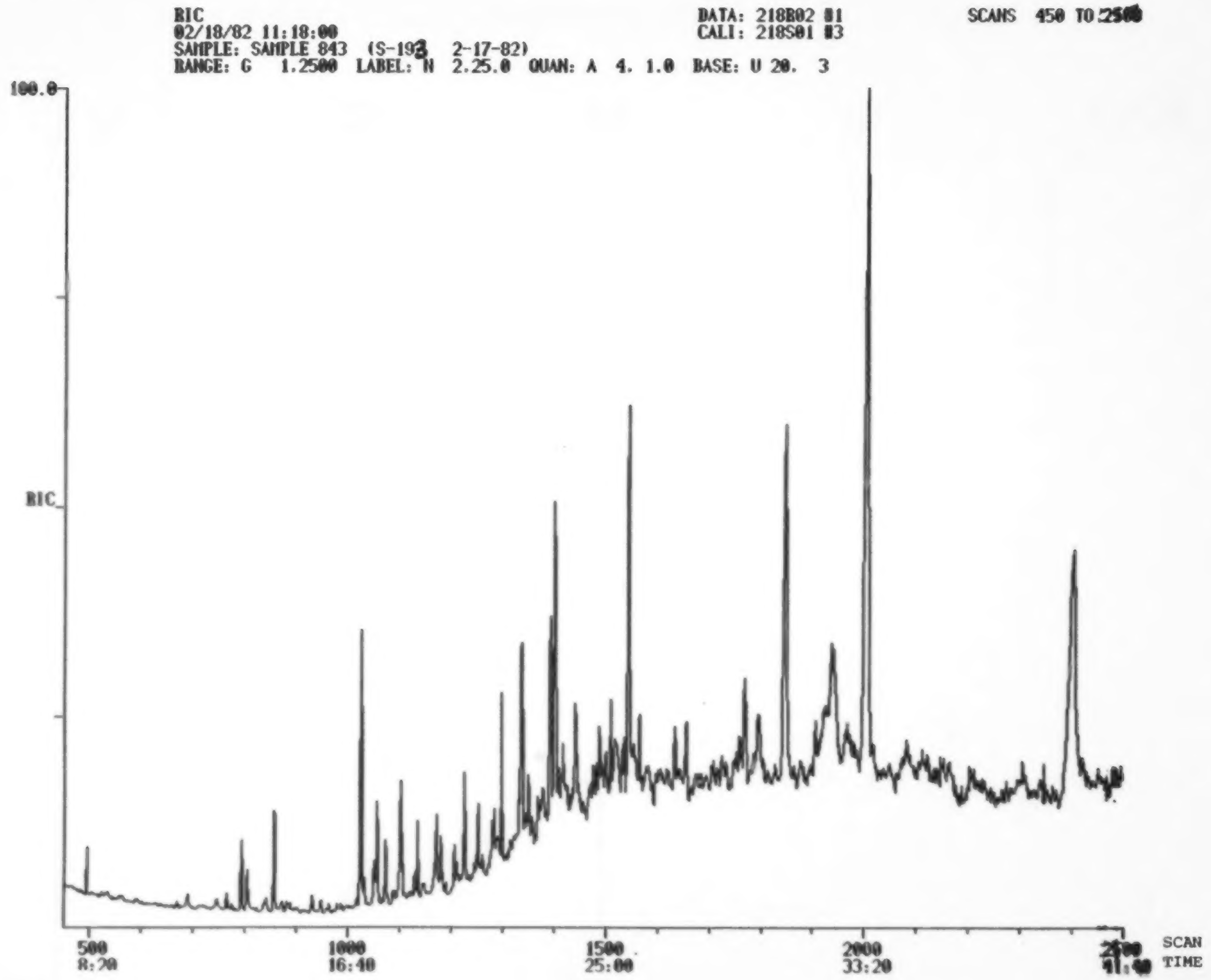

Figure 5. TIC chromatogram of extract S-193 (843) methane engine

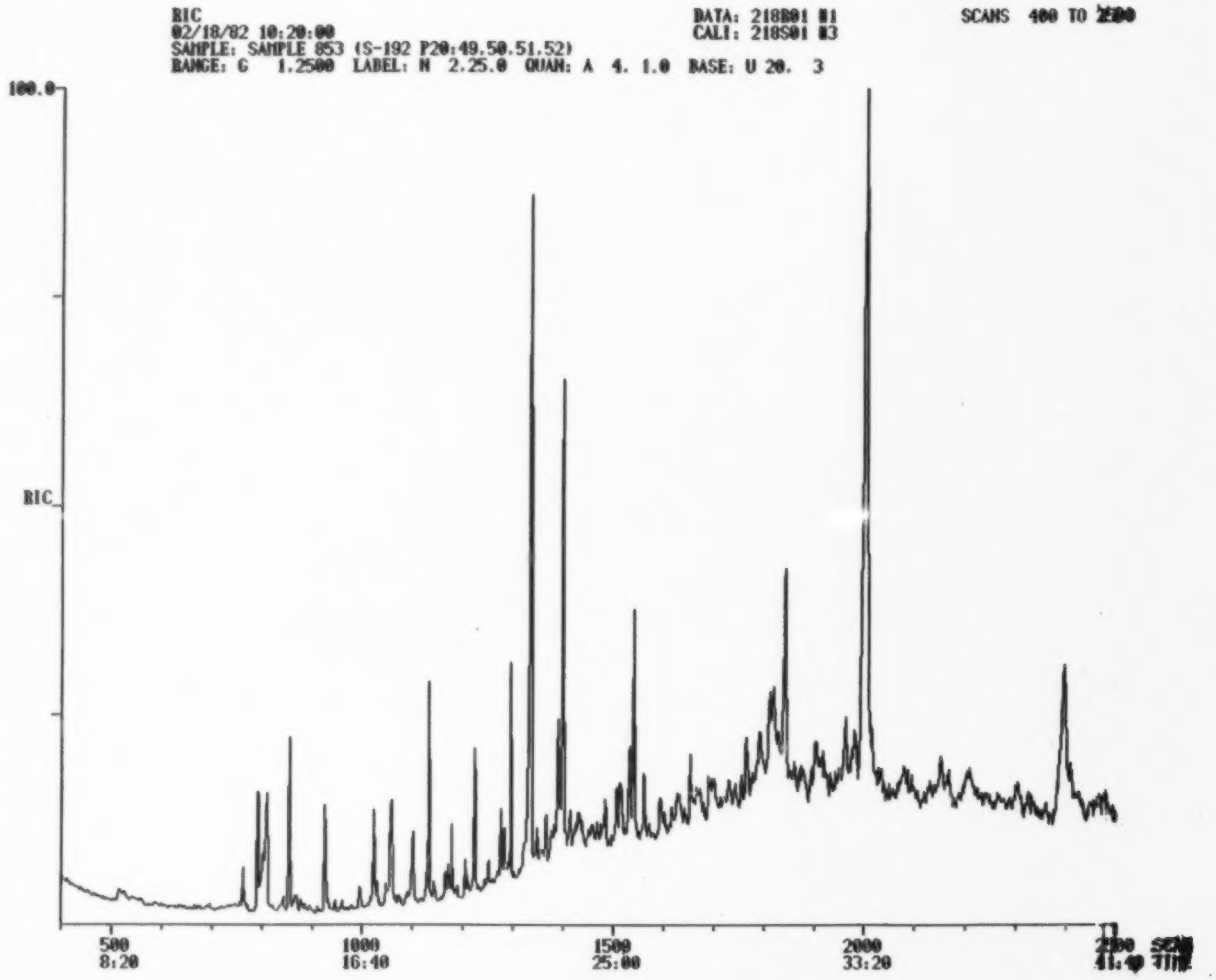

Figure 6. TIC chromatogram of extract S-192 (853) gasoline engine

APPENDIX G

AMES TEST RESULTS

As Reported to Craig Harvey EPA-Ann Arbor
by Timothy E. Lawlor, Microbiological Associates,
Rockville, Maryland

Sample I.D.	Car	Catalyst	Fuel
CABS-82-0010	Escort	Noble Metal	Indolene
CABS-82-0020	Escort	Noble Metal	Anafuel
CABS-82-0030	Escort	Noble Metal	Methanol
CABS 82-0040	Rabbit	Noble Metal	Methanol
CABS 82-0050	Rabbit	Noble Metal	Indolene
CABS 82-0060	Escort	P.B. Metal	Methanol
CABS 82-0070	Escort	None	Methanol
CABS 82-0080	Rabbit	P.B. Metal	Methanol

MICROBIOLOGICAL ASSOCIATES

Microbiological Associates
A Unit of Whittaker Corporation
5221 River Road
Bethesda, Maryland 20816
(301) 654-3400
Telex No. 90-8793

Whittaker

August 4, 1982

Craig Harvey
CTAB
Environmental Protection
 Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Craig:

Enclosed are statistical compilations for the following samples:

CABS-82-0010 - CABS-82-0080
CABS-82-0090 - CABS-82-0160
CABS-82-0180

If you have any questions, please don't hesitate to call.

Sincerely,

Timothy E. Lawlor

Timothy E. Lawlor
Rockville Laboratories

TEL:gr

enclosures

statistics entered by
P.J. Burke 8-3-82

Sample I.D.	Date Tested	Strain	Activation Lot Number	Model Predicted Slope			Linear Regression Predicted Slope (Mean)	Toxicity B_1 Value	Poisson Assumption Valid	Adequacy Criteria Met	4 Parameter Model Converged	3 Parameter Model Converged	2 Parameter Model Converged	Dose Range Tested (UGS)	Max Rev/Dose			Comments
				Low	Mean	High												
CABS-82-0010	2-25-82	TA98	RLI017	4.8	5.0	5.3	2.146	.00128		0.02	✓		✓	20 → 2000	1419/650			
CABS-82-0010	3-4-82	"	"	4.2	4.6	5.1	2.014	.00130		0.01	✓		✓	20 → 2000	1322/650			
CABS-82-0020	2-25-82	"	"	15.8	16.3	16.9	1.849	.00109	0.02		✓		✓	20 → 2000	3753/2000			
"	3-4-82	"	"	10.7	11.1	11.5	5.411	.00112			✓		✓	20 → 2000	3577/2000			
CABS-82-0030	2-25-82	"	"	0.6	0.9	1.4	0.260	.00060	0.05	✓	✓	✓	✓	20 → 2000	556/2000			
"	3-4-82	"	"	0.3	0.4	0.6	0.167	.00042	✓	✓	✓	✓	✓	20 → 2000	369/2000			
CABS-82-0040	2-25-82	"	"	4.4	5.2	6.0	0.646	.00103	✓	✓	✓		✓	20 → 2000	1314/2000			
"	3-4-82	"	"	2.3	2.9	3.7	0.571	.00081	✓	✓	✓		✓	20 → 2000	1168/2000			
CABS-82-0050	2-25-82	"	"	0.3	0.9	2.9	0.094	.00107	0.03	✓	✓	✓	✓	20 → 2000	225/2000			
"	3-4-82	"	"	0.3	0.6	1.0	0.261	.00113	✓	✓	✓	✓	✓	20 → 2000	201/2000			
CABS-82-0060	2-25-82	"	"	0.3	1.7	9.2	0.160	.00115	✓	✓	✓	✓	✓	20 → 2000	346/2000			
"	3-4-82	"	"	0.4	0.8	1.8	0.178	.00074	✓	✓	✓	✓	✓	20 → 2000	380/2000			
CABS-82-0070	2-25-82	"	"		4.5		1.099	.00071	✓			✓	✓	20 → 2000	2197/2000			
"	3-4-82	"	"	3.1	3.4	3.9	1.037	.00060	0.02		✓	✓	✓	20 → 2000	2078/2000			
CABS-82-0080	2-25-82	"	"	0.8	1.2	1.8	0.150	.00101	✓	✓	✓	✓	✓	20 → 2000	329/2000	304/650		
"	3-4-82	"	"	1.3	5.4	22.4	0.354	.00406	✓	✓	✓	✓	✓	6.5 → 650	251/650			

statistics entered by
P.J. Burke 8-3-82

Sample I.D.	Date Tested	Strain	Activation Lot Number	Model Predicted Slope			Linear Regression Predicted Slope (Mean)	Toxicity B₁ Value	Poisson Assumption Valid	Adequacy Criteria Met	4 Parameter Model Converged	3 Parameter Model Converged	2 Parameter Model Converged	Dose Range Tested (UGS)	Max Rev/ Dose			Comments
				Low	Mean	High												
CABS-82-0010	2-25-82	TA98			2.4		0.666	.00502		✓		✓	✓	20 → 2000	189/200			
"	3-4-82	"		2.3	2.8	3.3	0.640	.00216			✓	✓	✓	6.5 → 2000	450/650			
CABS-82-0020	2-25-82	"			16.4		3.315	.00243					✓	20 → 2000	2322/650			
"	3-4-82	"		7.8	7.9	8.1	3.346	.00123			✓		✓	6.5 → 2000	2223/650			
CABS-82-0030	2-25-82	"		0.4	0.7	1.1	0.173	.00063	✓	✓	✓	✓	✓	20 → 2000	388/2000			
"	3-4-82	"		0.2	0.3	0.4	0.193	.00022	✓	✓	✓	✓	✓	20 → 2000	416/2000			
CABS-82-0040	2-25-82	"		2.1	2.4	2.7	0.592	.00066	✓	✓	✓		✓	20 → 2000	1259/2000			
"	3-4-82	"		2.6	2.9	3.3	0.666	.00073	0.03		✓	✓	✓	20 → 2000	1357/2000			
CABS-82-0050	2-25-82	"		0.1	0.3	0.6	0.093	.00046	0.03	✓	✓	✓	✓	20 → 2000	222/2000			
"	3-4-82	"		0.1	0.1	0.1	0.069		0.03	✓		✓	✓	20 → 2000	160/2000			
CABS-82-0060	2-25-82	"		0.3	0.5	0.7	0.206	.00040	✓		✓	✓	✓	20 → 2000	440/2000			
"	3-4-82	"		0.4	0.6	0.9	0.203	.00051	✓	✓	✓	✓	✓	20 → 2000	418/2000			
CABS-82-0070	2-25-82	"		2.2	2.6	3.1	0.737	.00063		0.03	✓	✓	✓	20 → 2000	1441/2000			
"	3-4-82	"		1.8	2.0	2.2	0.759	.00047	0.01	0.01	✓	✓	✓	20 → 2000	1539/2000			
CABS-82-0080	2-25-82	"		0.2	0.3	0.4	0.117	.00036	✓	✓	✓	✓	✓	20 → 2000	257/2000	161/650		
"	3-4-82	"		0.2	0.5	1.5	0.154	.00160	✓	✓	✓	✓	✓	6.5 → 650	115/650			